

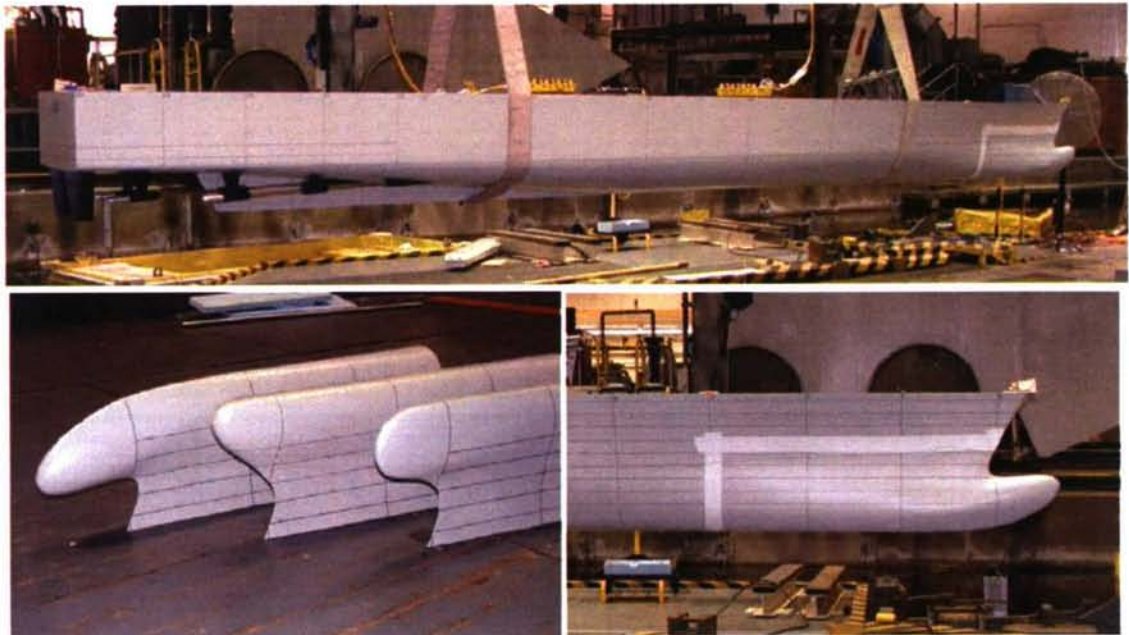
**Naval Surface Warfare Center
Carderock Division**
West Bethesda, MD 20817-5700



NSWCCD-50-TR-2007/066 August 2007
Hydromechanics Department Report

**Joint High Speed Sealift (JHSS)
Baseline Shaft & Strut (Model 5653) Series 1:
Bare Hull Resistance, Appended Resistance, and
Alternative Bow Evaluations**

By
Dominic S. Cusanelli



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ABSTRACT

Model 5653, scale ratio 34.121, was constructed representative of the Joint High Speed Sealift (JHSS) conventional Baseline Shaft & Strut (BSS) hullform. This report documents the Series 1 testing conducted in FY06 for the initial evaluation of the JHSS BSS hullform. Series 1 Tests included fully appended resistance, appendage stripping, bare hull resistance, and alternate bow evaluations and selection.

The BSS hullform was evaluated with four candidate bows, which included three bulb designs and a stem bow (no bulb). All bow configurations were tested at three ship displacements. The Gooseneck Bulb (GB) was selected for the JHSS BSS based primarily upon the criteria of minimum effective power at 36 knots, for all tested displacements.

Effective power predictions for the bare hull and fully appended configurations of the BSS hullform with baseline bulb (BB) were compared to pre-test estimates.

ADMINISTRATIVE INFORMATION

Primarily, funding for the various studies and tests that will be performed under this project comes from the JHSS Project Office, NAVSEA 05D1, Project Manager Steven Wynn. The JHSS Hydro Working Group (HWG), which includes representatives from NAVSEA, NSWCCD, ONR and CSC, coordinates all hydrodynamic, propulsion, hull form and structural loads R&D for the JHSS program. Series 1 testing was conducted at the David Taylor Model Basin, Naval Surface Warfare Center, Carderock Division Headquarters, (NSWCCD), by the Resistance & Powering Division (Code 5200) under job order 06-1-2123-405.

INTRODUCTION

The Joint High Speed Sealift (JHSS) is a potential FY12 ship acquisition sponsored by OPNAV N42. The program was begun in FY04 and was originally designated the Rapid Strategic Lift Ship (RSLs). The "Rapid Strategic Lift Ship Feasibility Study Report" [Ref. 1] was published in February 2005. In the "Joint High Speed Sealift (JHSS)" presentation [Ref. 2], the ship's capability was broadly described as being able to "Embark design payload, transport it 8,000 nm at 36 knots or more, and disembark it to a seabase or shore facility". Though a sustained speed of 36 knots is required, speeds as great as 40 knots are of interest.

The Baseline Shaft & Strut (BSS) hullform is the first tested of three different propulsion systems that are being evaluated for the combined JHSS and Sealift R&D Programs. These three propulsion systems are (1) the conventional shaft and strut configuration, (2) waterjet propulsion (both axial flow and mixed-flow jets), and (3) podded propulsion. The hullform explanations and development is presented in the initial FY06 JHSS report.¹

This report documents the JHSS Series 1 testing conducted in FY06, by the Resistance & Powering Department (Code 5200), to evaluate and contribute to the design of the conventional BSS hullform. Series 1 Tests included fully appended resistance, appendage stripping, bare hull resistance, and alternate bow evaluations and selection. Additional JHSS BSS tests to be conducted within the closing weeks of FY06 will be the Series 2 Laser Doppler Velocimetry (LDV) propeller disk wake surveys conducted by the Propulsion and Fluid Systems Department (Code 5400), which will be reported in a subsequent document.

Results from these tests will be used in future JHSS design iterations and more generally under an associated program intended to develop and validate computational design/evaluation tools. These tools could then be used with a higher degree of confidence to evaluate, for

¹ McCallum, D. et. al., "Joint High Speed Sealift (JHSS) Progress Report - Summary of Hullform Development" (Report in preparation).

example, designs submitted by industry as a response to a Request for Proposal (RFP). Therefore, these concept designs are also intended to represent actual designs that could be expected from industry.¹

HULL MODEL

Description

Resistance and propulsion Model 5653, representative of the JHSS baseline shaft and struts (BSS) hullform, built of fiberglass to a linear scale ratio $\lambda = 34.121$, and LBP = 27.86 ft (8.5 m), was manufactured at NSWCCD. This scale ratio was based on the availability of 7.5 inch (19.05 cm) diameter high quality model propellers designed and manufactured for the PC 1 program. These were the selected model stock propellers for the JHSS BSS powering tests. Photographs of Model 5653, while under construction, are presented in Appendix A, Figure A1. A photograph of Model 5653, the completed bare hull shell, is presented in Figure 1.



Fig 1. JHSS BSS Model 5653, bare hull shell



Fig 2. JHSS BSS Model, 5653, bow cut-out

Model 5653 was modified with a cut-out in the bow area so as to accept interchangeable bow designs, Fig 2. Four candidate bows, which included three bulb designs, Baseline Bulb (BB), Elliptical Bulb (EB), Gooseneck Bulb (GB), and a stem bow (ST), were designed and manufactured for the Series 1 tests. Photographs of all four candidate JHSS BSS bow designs, installed on Model 5653, are presented in Appendix A, Figure A2. The three candidate bulb designs are shown in Figure 3.

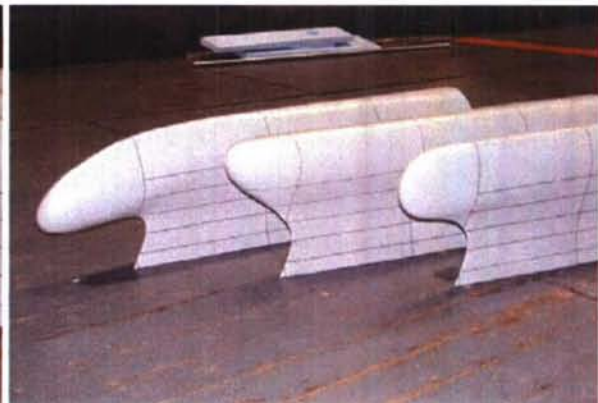
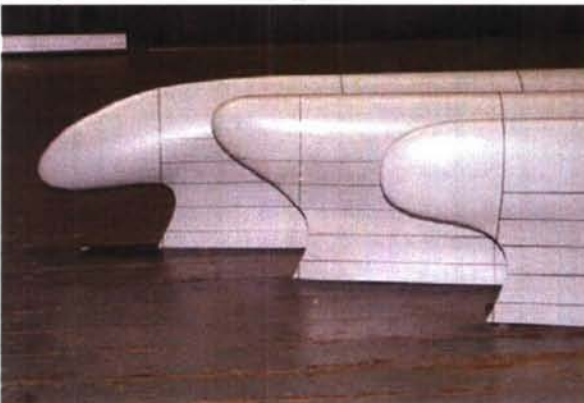


Fig 3. JHSS BSS candidate bulb designs

All candidate bows were assigned names, abbreviations, and numeric model number suffixes, as described in Table 1. Table 1 is an excerpt from the complete listing of descriptions and

abbreviations assigned to models, propulsion configurations, appendages, and loading conditions, for the combined JHSS and Sealift R&D programs, Appendix A, Table A1.

Table 1. JHSS BSS candidate bow designs, appendage configurations, and loading conditions tested during Series 1

JHSS Baseline Model	Model Number	Abbreviation
Baseline Shaft & Strut Hull, Open Propellers (full model)	5653	BSS
w/ Baseline Bulb (insert)	5653	BB
w/ Stem Bow – no bulb (insert)	5653-1	ST
w/ Elliptical Bulb (insert)	5653-2	EB
w/ Gooseneck Bulb (insert)	5653-3	GB

JHSS Appendages / Configurations	Abbreviation
Fully Appended (all associated appendages installed)	FA
Bare Hull (No appendages, hull penetrations sealed)	BH
Propulsion Shaftlines (4): Open Shafts, Struts, Barrels	S&S
Rudders (2): Installed Zero degrees (parallel to CL)	RUD

JHSS Loading Conditions	Long Tons	Abbreviation
Design Displacement	36491	DES
Heavy Displacement (Design +10%)	40140	HVY
Light Displacement (Design -10%)	32841	LITE

Hull penetration pockets and holes, for the installation of the propulsion shaftlines, support struts and bossings, and the rudders, were cut into the hull shell with the NC machine to insure accuracy. The propulsion shaftlines and rudders were manufactured as removable / replaceable so as to accommodate the required appendage stripping and bare hull experiments. The fully appended (FA) model is defined with the following appendages installed on the hull. Four (4) propulsion shaftlines and struts (S&S), including non-rotating external shaft tubes [brass], rotating shafts [stainless steel], struts, main strut barrels, and shaft bossings [all of SLA² plastic]. Two (2) rudders (RUD) [SLA] installed at zero degrees (parallel to ship centerline).

A modification was made to the original supplied rudder design. The original design and location of the rudder placed it into a position of interference with the propeller hub. The rudder position was moved aft to allow for the minimum clearance required between the rudder leading edge and the shaftline, to accommodate the removal of the propeller hubs. The closer proximity of this aft rudder position to the transom necessitated that the rudder chord length be reduced to 68% that of the original design.

To accommodate the bare hull (BH) test configuration, the shaft strut installation pockets were filled with custom-fit low-density styrofoam plugs, which were cut flush to match the local model surface contour. All hull penetrations and the styrofoam plugs were then covered and faired into the hull surface with 4-inch wide heat-treated white tape.

To produce turbulent flow along the model, turbulence stimulator studs of 1/8 inch diameter by 1/10 inch height, spaced 1 inch apart, were affixed to the model approximately 2 inches aft of the stem, and continuing down to and around the bulbs approximately 2 inches aft of the FP.

A photographic reference grid was painted on the model. The vertical grid consisted of station lines (marked with station numbers) at every station 0 to 6, then stations 8, 10, 12, 14, and again every station 16 to 20. The horizontal grid consisted of a full-length waterline drawn at a

² Fabricated by Stereo Lithographic Apparatus (SLA). Material is Accura S140, an engineered plastic designed to mimic the properties of 6:6 Nylon.

draft of 8.6m (28.22 ft), the design waterline (DWL) at the time of model construction. Between stations 0 to 6 and 16 to 20, additional waterlines were drawn at 2 m (6.56 ft) increments above and below the drawn DWL.

Model Hull Inspection

Due to the delivery of Model 5653 just prior to the scheduled start of Series 1 testing, adequate time was not available for a laser inspection of the model surface prior to the experiments. Series 2 LDV wake surveys and Series 3 stock propeller powering, which were scheduled to follow in rapid succession, also did not allow for an adequate window for inspection. Therefore, the laser inspection will be conducted after the Series 3 tests, and will be reported in a subsequent document. A pre-test visual inspection was completed by the Model-Test Engineers (Codes 5200), and Model 5653 was judged to be acceptable for testing.

Instrumentation and Outfitting

The linear bearing, floating platform "Cusanelli" tow post [Ref. 3], was utilized for the forward attachment point of the model to the towing carriage. Mechanical connection between the tow post and model was made through a double-axis gimbal assembly. When attached through the floating platform tow post system, the model is restrained in surge, sway, and yaw, but is free to pitch, heave, and roll. The location of the model tow point was at ship Station 5, parallel to, and at the same level as, the original 8.6m (28.22ft) DWL. For the aft attachment point, the standard 'grasshopper' bracket was utilized, attached at ship Station 15. The counter weights and vertical arm were balanced, in place, so that the arm would not impart any vertical force on the model.

Specifications for the model instrumentation and calibrations were determined through discussions between the test engineer and the instrumentation personnel, from supplied information based on pre-test estimates and past experience, requirements dictated by the specific model size and force limitations, and available instrumentation capacities. Instrument Calibration was performed prior to the tests in the NSWCCD Code 5200 calibration lab by D. Mullinix (CSC contractor).

Model resistance (drag) measurements were collected using a DTMB 4-inch block gauge, of 200 lbf. capacity. Model side force measurements were collected with a DTMB 4-inch block gauge, of 50 lbf. capacity. Side force is monitored at the tow post attachment point during calm water experiments in order to maintain an essentially zero side force to insure zero yaw angle. Dynamic sinkage (defined as positive downward) was measured by wire potentiometers, which were located at the intersection of the deck line at Station 1 forward and Station 15 aft. Vertical difference between the forward and aft measurement points was used for the calculation of running pitch angle.

Vessel displacement and trim

Model tests were conducted at three displacement conditions, as outlined in the aforementioned Table 1. A design displacement (DES) of 36,491 tons was determined to be representative of a likely loading scenario for the JHSS BSS. The heavy displacement (HVY) of 40,140 tons and light (LITE) displacement of 32,841 tons represented ± 10 percent variations in displacement from design. All conditions were tested at even keel (zero static trim).

Hydrostatic calculations were performed for the JHSS BSS with each of the candidate bow designs, at the three displacements. Design displacement hydrostatic tables are presented in Appendix A, Tables A2-A5. Ship/model test parameters, for all bow configurations, at the three displacements, are presented in Appendix A, Tables A6-A9. Model ballasting was adjusted so as to represent the specified ship displacement.

RESISTANCE TESTS

Resistance experiments were conducted on Model 5653 and analyzed according to standard NSWCCD practice for this type of vessel as set fourth by Grant and Wilson [Ref. 4]. The BSS Series 1 Test Agenda is presented as Appendix B, Table B1. All Series 1 resistance tests were conducted through the entire ship speed range of 15 knots through 45 knots, as requested by the JHSS Hydro Working Group (HWG). Results of the Series 1 resistance tests are presented in their entirety in Appendix B, Figures B1-B18 and Tables B2-B19.

Tests were conducted at the NSWCCD Deepwater Towing Basin #2 using Carriage 2. The cross-sectional area of the tank will provide sufficient area to eliminate the need for block correction. Photographs of Model 5653 installed under Carriage 2 in the Deep Water Basin #2, for resistance and powering tests, are presented in Appendix A, Figure A4.

The ship-model correlation allowance of $C_A = 0.0$ was recommended by NSWCCD Code 5200 based on the NAVSEA guidance and recent correlation allowance experience with 4-screw hullforms. The value of $C_A = 0.0$ was agreed upon by the JHSS HWG.

Resistance Comparisons, Pre-Test Estimates

Fully appended (FA) resistance and bare hull (BH) resistance experiments were conducted on JHSS Model 5653, Baseline Shaft & Strut (BSS) with Baseline Bulb (BB), at design displacement. Results of the FA and BH conditions, Tables B2 and B5, respectively, were compared to pre-test estimates prepared for the HWG. These comparisons are presented in Appendix A, Figures B1 and B2, and summary Table B17. In the FA configuration, the Model 5653 test exhibited a resistance lower than that of the pre-test estimate, in the range of 6% lower at high speed, to as much as 17% lower at 24 knots. BH resistance was as much as 13% lower than that of the pre-test estimate, in the range of 15 to 33 knots; it was approximately equivalent between 34-35 knots; and it was slightly higher at speeds of 36 knots and above. On average across the entire speed range, the BH model tests exhibited a resistance approximately 5% lower than that of the pre-test estimate.

The JHSS baseline bare hull resistance pre-test prediction, prepared by Fung³, was based on speed-independent regression equations. Its predicted residuary resistance coefficient was a function of on the ship's hull form parameters, e.g., displacement-length ratio, beam-draft ratio, prismatic coefficient, maximum section area coefficient, half-entrance angle, bulbous bow/bow dome transverse section area/vertical location, and transom configuration.

Displacement Effects

Bare hull (BH) resistance tests were conducted on JHSS Model 5653 at three displacement conditions, design (DES), heavy (HVV) and light (LITE). DES displacement was 36,491 tons, while HVV and LITE displacements represented ± 10 percent variations from design. These displacement variations were tested on all four candidate bow designs. For the JHSS BSS with Baseline Bulb (BB), the 10% increase in displacement resulted in a 10.5% average increase in resistance across the speed range, and conversely, the 10% reduction in displacement resulted in an average 6.2% reduction in resistance. Displacement effects were similar for the remaining candidate bow designs. Displacement effects on resistance are reported in their entirety, in Appendix B, Table B17.

Candidate Bow Performance Evaluations and Selection

Bare hull (BH) resistance tests were conducted on JHSS BSS Model 5653 with four candidate bows, which included three bulb designs, Baseline Bulb (BB), Elliptical Bulb (EB),

³ Fung, S. "prediction method / basis for JHSS baseline hull resistance estimate" email dated 11 Dec, 2006.

Gooseneck Bulb (GB), and a stem bow (ST). Tests were conducted at all three displacement conditions, design (DES), heavy (HVY) and light (LITE). Results are presented in Appendix B, Figures B3-B10, and Tables B4-B15. Summary and comparisons of all candidate bows are presented in Figure B11 and Table B17. A summary of candidate bows performances, at design displacement, is presented in Table 2, and Figure 4.

Table 2. JHSS BSS summary of candidate bows, performance at design displacement

Speed (knots)	JHSS BSS, Design Displacement, Bare Hull				Bow Bulbs vs. Stem Bow		
	ST	BB	EB	GB	BB/ST	EB/ST	GB/ST
	PE (hp)	PE (hp)	PE (hp)	PE (hp)	PE Ratio	PE Ratio	PE Ratio
15	5267	5600	5156	5594	1.063	0.979	1.062
20	12798	12765	12020	12102	0.997	0.939	0.946
25	25711	24356	23753	23494	0.947	0.924	0.914
30	43777	41378	41080	40248	0.945	0.938	0.919
35	70451	68010	67645	66855	0.965	0.960	0.949
40	145768	138770	138730	136626	0.952	0.952	0.937
45	271492	261226	258971	254968	0.962	0.954	0.939

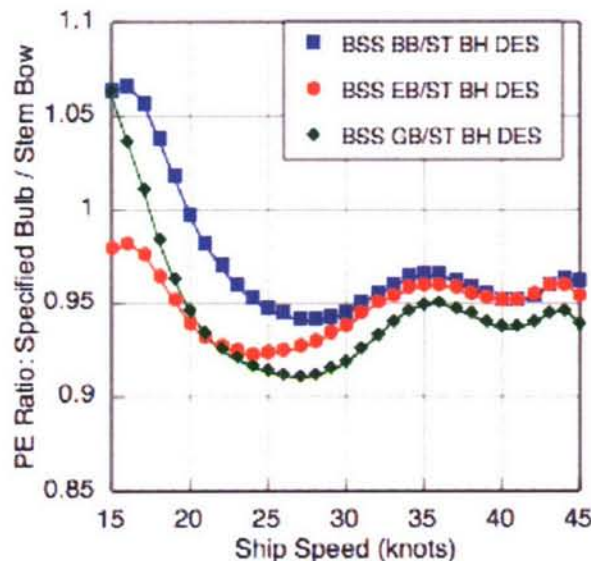


Fig 4. JHSS BSS candidate bows comparative performances, design displacement

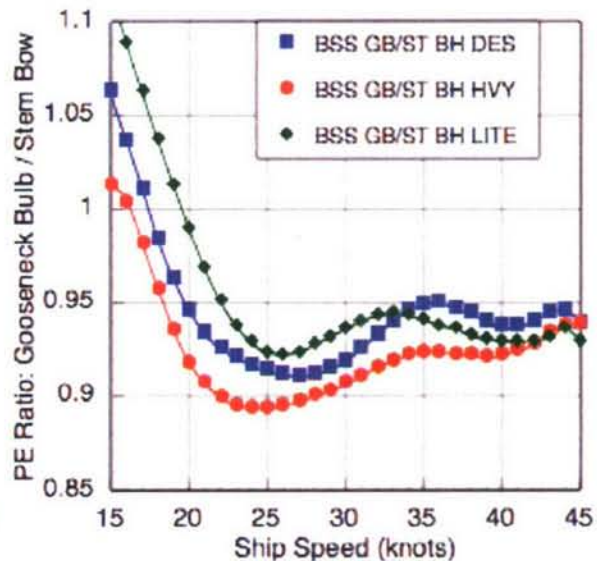


Fig 5. JHSS BSS selected Gooseneck Bulb (GB) performance, three displacements

In Appendix B, comparisons were made between the resistance predictions of each bow design relative to the pre-test estimates, and also to that of the stem bow (no bulb), in order to assist in the selection of a bulb for continued testing in the JHSS program. The bulb section criteria, as modified by the HWG, was as follows:

1. Achieve the lowest resistance at 36 knots at both Design and Light conditions
2. The resistance penalty shall be the minimum at speeds of 20 knots when compared to the no bulb (stem bow) configuration at both Design and Light condition.

Based on this bulb section criteria, the Gooseneck Bulb (GB) was selected for continued testing in the JHSS program. Of all the bow designs, the GB exhibited the minimum effective power at 36 knots, for all tested displacements, Figure 5, and therefore, exceeded the first criteria. Although the GB did exhibit increased resistance over the stem bow at very low speeds, it did not show an increase in resistance at 20 knots for any of the tested displacements, thus fulfilling criteria 2. Photographs of JHSS BSS with selected Gooseneck Bulb (GB), Model 5653-3, are presented in Figure 6, with additional photographs in Appendix A, Figure A3.

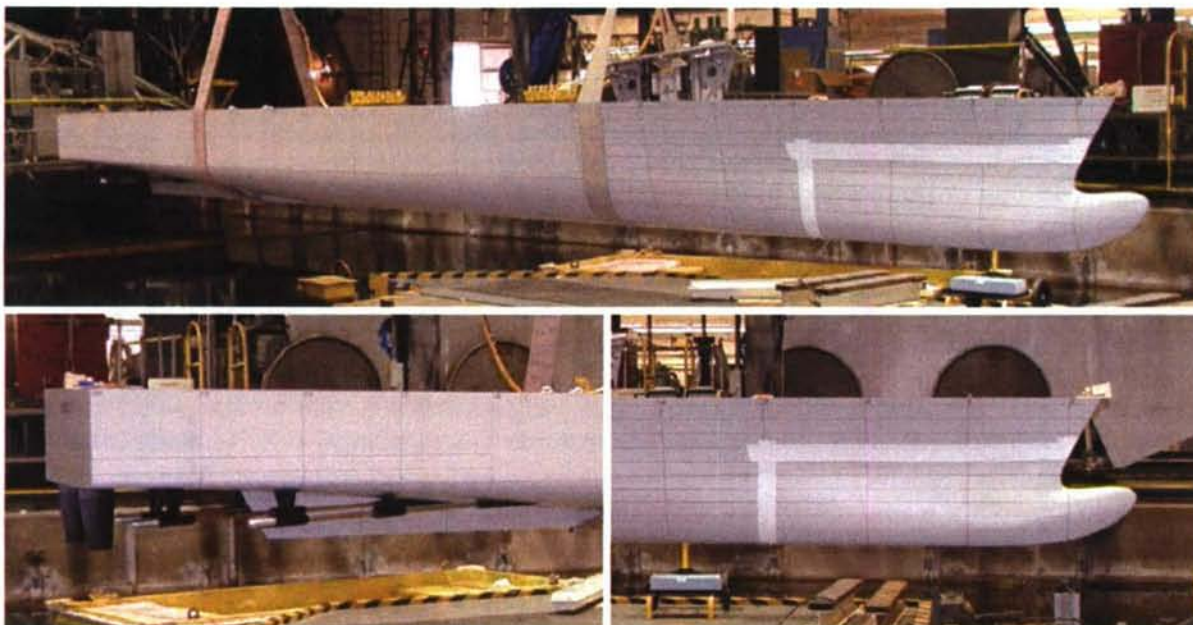


Fig 6. JHSS BSS with selected Gooseneck Bulb (GB), Model 5653-3

Appendage Resistance

An ‘appendage stripping’ series of experiments was conducted on JHSS Model 5653 BSS with Baseline Bow (BB), at design displacement (DES). The initial experiment was conducted with the model in the fully appended configuration. Individual appendage components were then sequentially ‘stripped’ off and the subsequent resistance test results were used to determine individual appendage drag.

For the JHSS Model 5653 BSS BB, the total increase in resistance for all appendages combined, expressed as a percent increase relative to bare hull resistance, ranged from approximately 15% at the top end of the speed range to greater than 33% in the lower third of the speed range. On average across speed, the total increase in resistance due to appendages was 28.3%. The individual appendage resistance contributions, averaged across speed, were an increase of 4.2% for the twin rudders, and 24.1% for the four propulsion shaftlines. Complete results of the appendage stripping experiments are presented in Appendix B, Table B17.

Dynamic Sinkage and Pitch

The dynamic sinkage at the forward (FP) and aft (AP) perpendiculars, and resultant pitch angles, were measured during all JHSS BSS Series 1 resistance tests. Results are presented individually for each of the four candidate bows in Appendix B, Figures B13-B16, and collectively in Table B18.

Wave Traces

Wave traces along the JHSS BSS Model 5653 surface were drawn between the forward (FP) and aft (AP) perpendiculars, for all four candidate bow designs, at DES displacement, at the 36 knot ship speed of interest. Resultant wave trace heights on the hull surface are presented in Figure B17 and Table B19. The wave trace heights were then used in combination with the dynamic sinkage at the forward (FP) and aft (AP) perpendiculars, to determine the equivalent local wave height generated by each candidate bow, presented in Figure B18 and Table B19.

A comparison between the four candidate bow designs reveals that the Baseline Bulb generated the highest peak local wave height of 11.1 ft above the still water surface, while the

stem bow generated the lowest at 9.3 ft. The peak local wave height generated by the selected Gooseneck Bulb was 10.3 ft above the still water surface.

COMPARISON TO PREVIOUS HIGH-SPEED SHIP DESIGNS

A comparison of the resistance performance of the JHSS to that of previous ship designs was prepared by Fung⁴. The evaluation is in the form of Worm Curve Factor (WCF) comparisons of the JHSS to other famous high-speed ships (SS United States, SL 7, CVN 76, DDG 51, and CGN 9 etc.) All of the JHSS BSS bow variants, including the Stem Bow, have superior WCF values to the ships in this grouping, as shown in Fig. 7.

WCF is the residuary resistance of a ship, compared to the residuary resistance of an equivalent Taylor Standard Hull, which has the same length, beam, draft, displacement, and prismatic coefficient. Ships with WCF values of less than 1.0 indicates that the ship has better residuary resistance characteristics than the comparable Taylor Standard Series hull. Usually, a ship is considered to have good residuary resistance characteristics when its WCF values are <0.9. A ship is considered exemplary when its WCF values are <0.8. WCF values of less than 0.75 are very unusual. The WCF of the JHSS is quite often less than 0.65 at speed-length ratios larger than 1.0. (The design speed-length ratio of the JHSS is approximately 1.2).

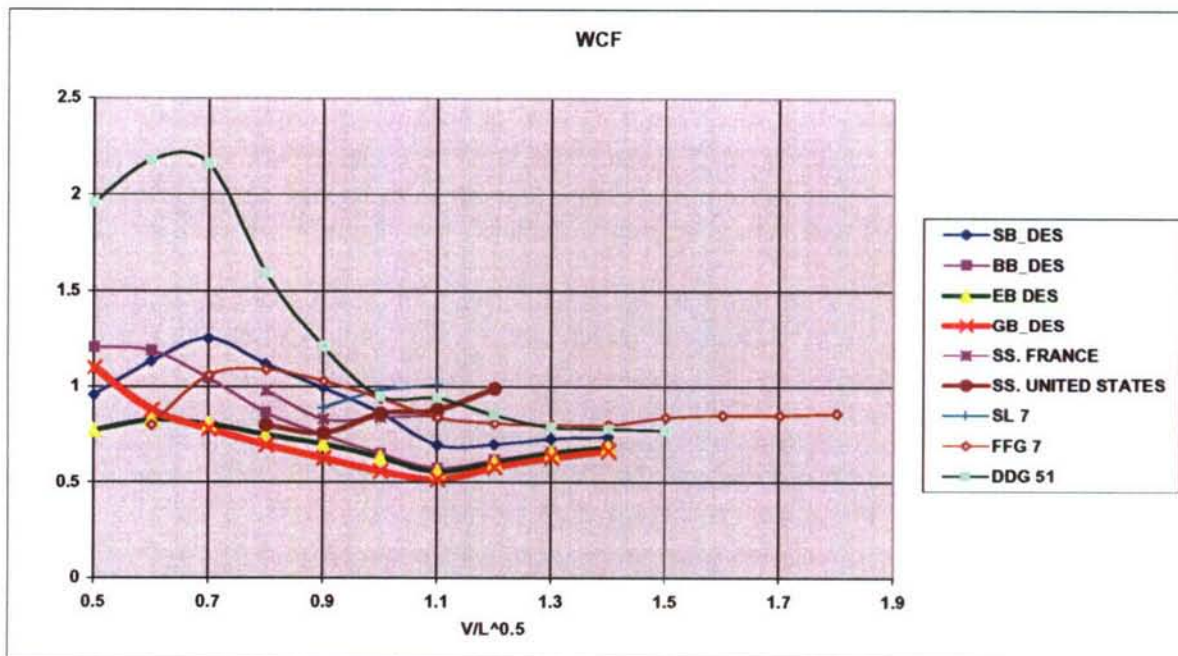


Fig 7. Worm Curve Factor (WCF) comparisons of the JHSS to other famous high-speed ships

⁴ "JHSS WCF COMPARISONS" email w/Excel file attachment, prepared by S. Fung (Code 2420), 06 Oct, 2006.

CONCLUSIONS

Model 5653, scale ratio 34.121, was constructed to represent the Joint High Speed Sealift (JHSS) conventional Baseline Shaft & Strut (BSS) hullform. Model 5653 was constructed with four interchangeable candidate bows, which included three bulb designs, Baseline Bulb (BB), Elliptical Bulb (EB), Gooseneck Bulb (GB), and a stem bow (ST).

Fully appended (FA) resistance and bare hull (BH) resistance experiments were conducted on JHSS Model 5653, BSS BB, at design displacement, and compared to pre-test estimates prepared by the JHSS Hydro Working Group (HWG). On average across the entire speed range, the FA model tests exhibited a resistance approximately 13% lower than that of the pre-test estimate, while similarly, the BH model tests exhibited a resistance approximately 5% lower.

Bare hull resistance tests were conducted on JHSS Model 5653 at three displacement conditions, design (DES) 36,491 tons, heavy (HVY), and light (LITE), which represented ± 10 percent variations from design. For the JHSS BSS BB, the 10% increase in displacement resulted in a 10.5% average increase in resistance across the speed range, and conversely, the 10% reduction in displacement resulted in an average 6.2% reduction in resistance.

Bare hull resistance tests were conducted on JHSS BSS Model 5653 with four candidate bows, at all three displacement conditions. Based on the bulb section criteria (primarily minimum resistance at 36 knots sip speed), the Gooseneck Bulb (GB) was selected for continued testing in the JHSS program.

An 'appendage stripping' series of experiments was conducted on JHSS Model 5653 BSS BB, DES displacement. The total increase in resistance for all appendages combined, expressed as a percent increase relative to bare hull resistance, averaged across speed, was 28.3%.

An evaluation of the resistance performance of the JHSS, expressed in the form of a comparison of Worm Curve Factor (WCF) to that of other famous high-speed ships, was prepared. All of the JHSS BSS bow variants, including the Stem Bow, have superior WCF values to the ships in this grouping.

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3. Cusanelli and Bradel, "Floating Platform Tow Post" United States Patent No. 5,343,742 (Sept. 6, 1994)
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APPENDIX A

MODEL CONSTRUCTION & SET-UP

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Model 5653 mold, starboard half



Model 5653 mold, starboard half

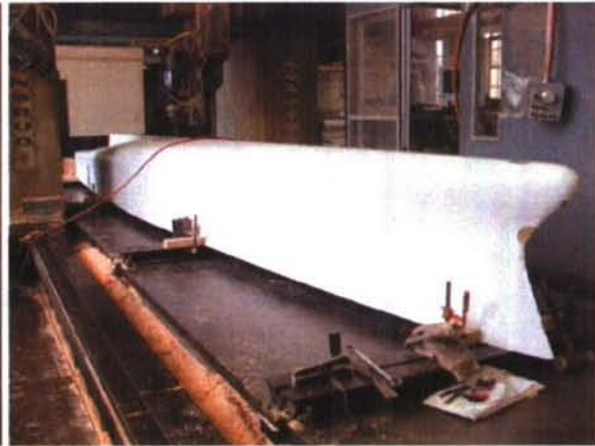
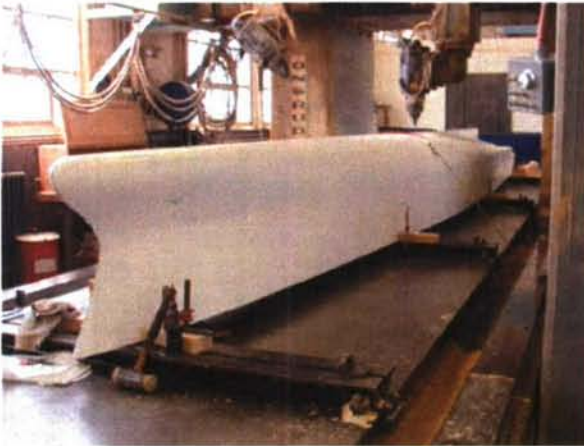


Model 5653 fiberglass shell in mold

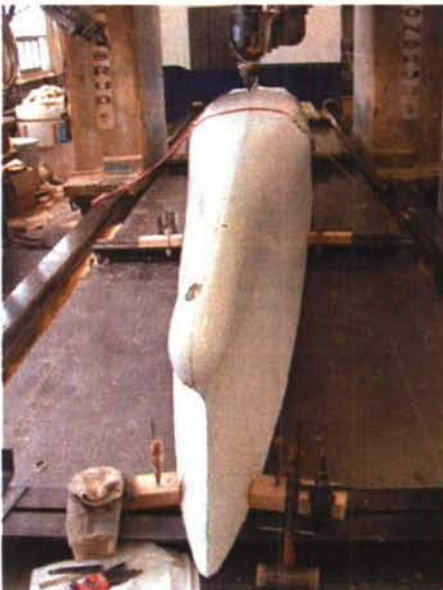


Elliptical bulb insert (EB), Model 5653-2

Fig A1. JHSS BSS Model 5653 under construction



Model 5653 fiberglass shell removed from mold



Model 5653 fiberglass shell removed from mold



Model 5653 fiberglass shell removed from mold

Fig A1. JHSS BSS Model 5653 under construction (continued)



Stem bow (ST) insert, Model 5653-1



Elliptical bulb (EB) insert, Model 5653-2

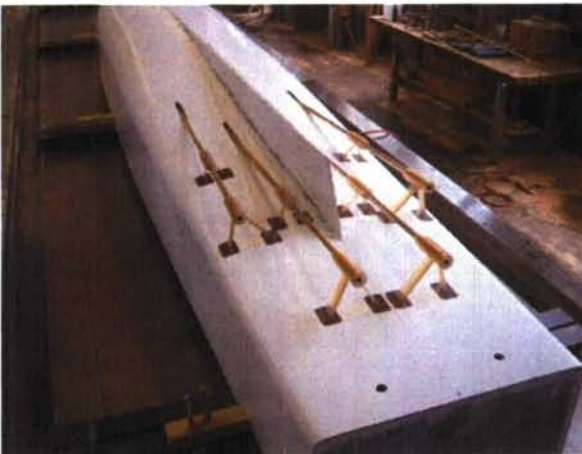


Wood block for Gooseneck bulb (GB) insert, Model 5653-3

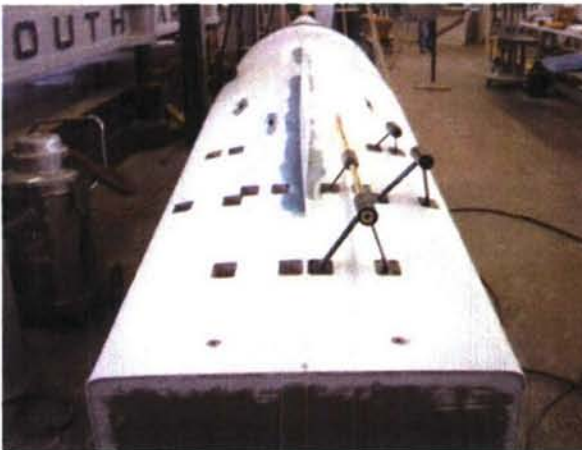
Fig A1. JHSS BSS Model 5653 under construction (continued)



Stock Open Propulsion (SOP), shaftline struts and barrels manufactured in SLA, in curing oven



Fitting/installation of Stock Open Propulsion (SOP), shaftlines, struts and barrels

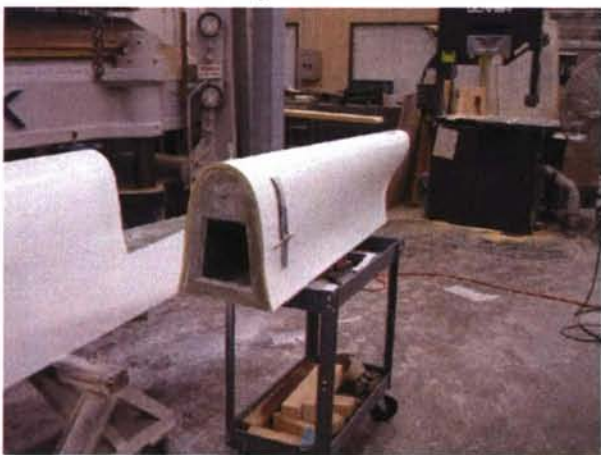


Fitting/installation of Stock Open Propulsion (SOP), shaftlines, struts and barrels

Fig A1. JHSS BSS Model 5653 under construction (continued)



Model 5653 forebody cut-out for bow inserts



Fitting Baseline Bulb (BB) into forebody cut-out



Rudders (RD), redesigned

Fig A1. JHSS BSS Model 5653 under construction (continued)



Model 5653 nearing completion

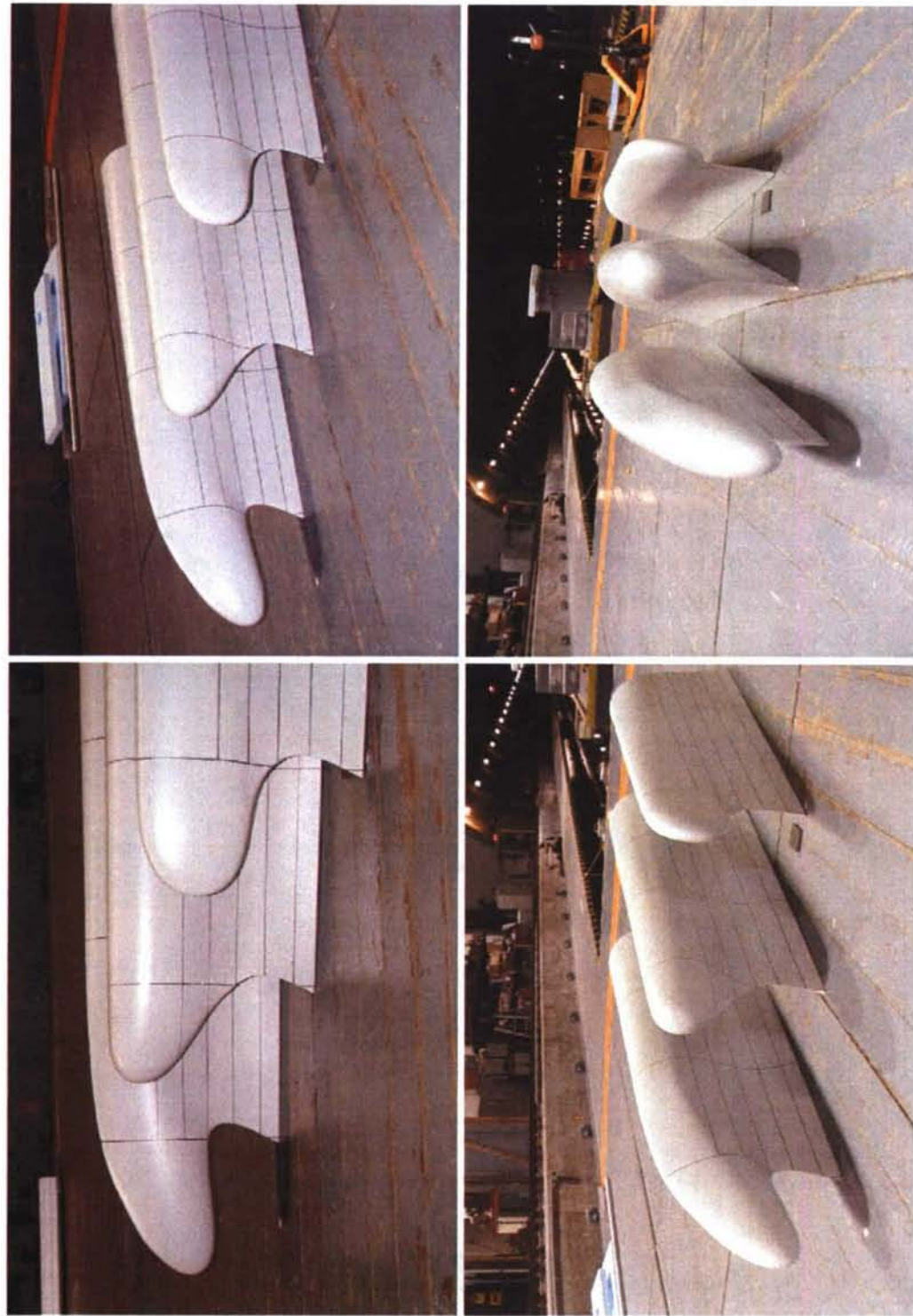


Photo grid drawn on Model 5653



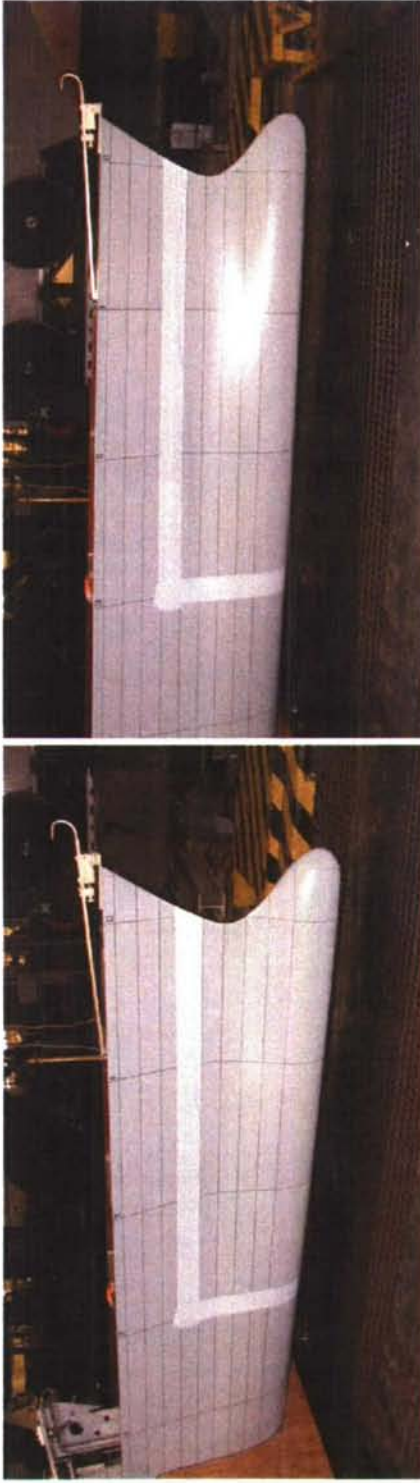
Stock Open Propulsion (SOP) installed

Fig A1. JHSS BSS Model 5653 under construction (continued)



Left-to-right: Gooseneck Bulb (GB) Model 5653-3, Baseline Bulb (BB) Model 5653-2, and Elliptical Bulb (EB) Model 5653-2

Fig. A2. JHSS BSS bow design variations, dry-dock photographs



Baseline Bulb (BB) installed, Model 5653

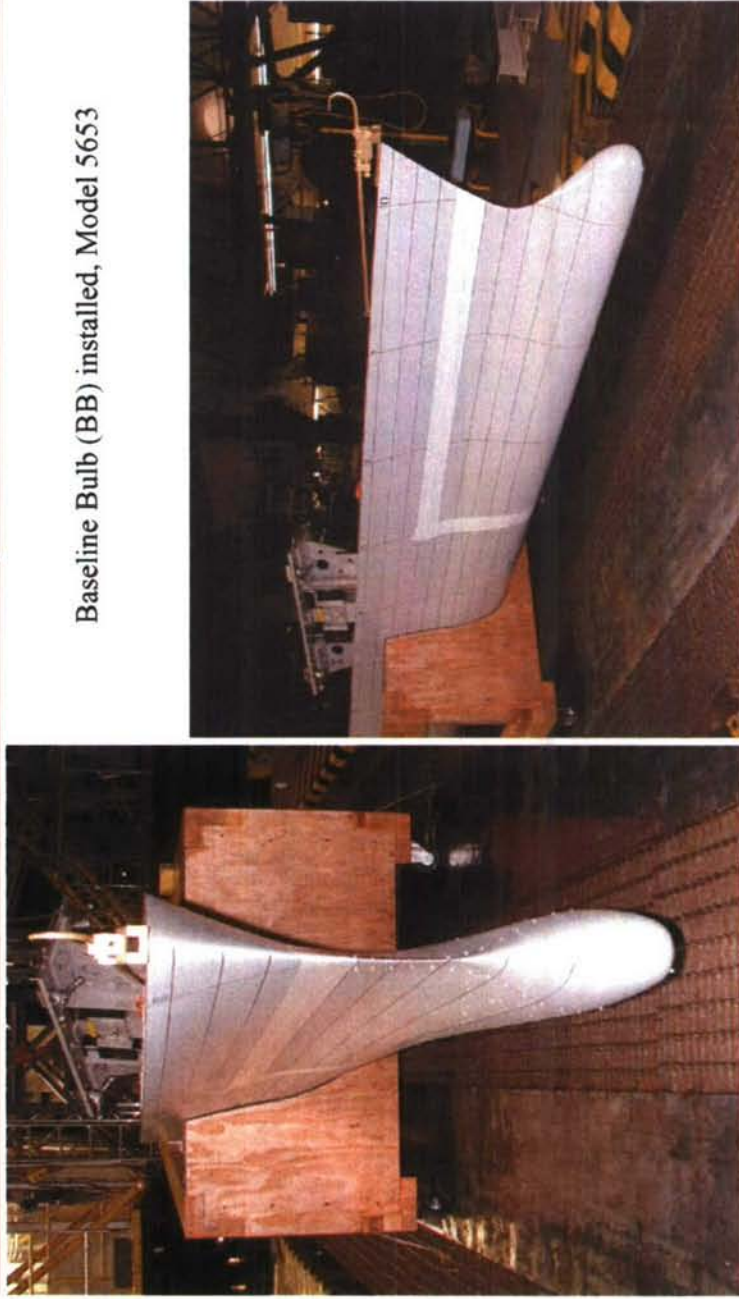
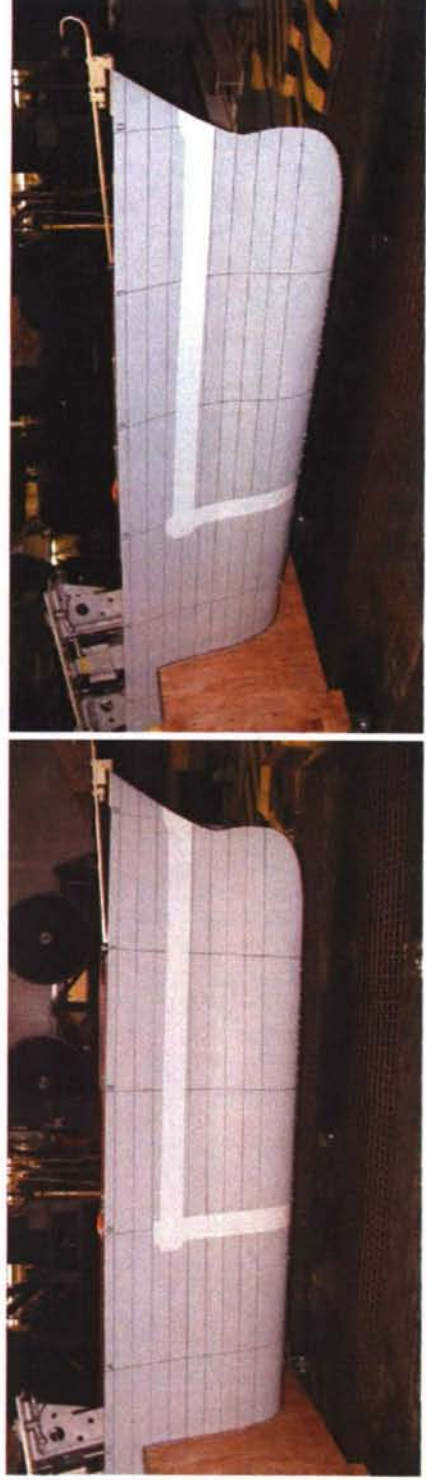


Fig. A2. JHSS BSS bow design variations, dry-dock photographs (continued)



Stem Bow (ST) installed, Model 5653-1

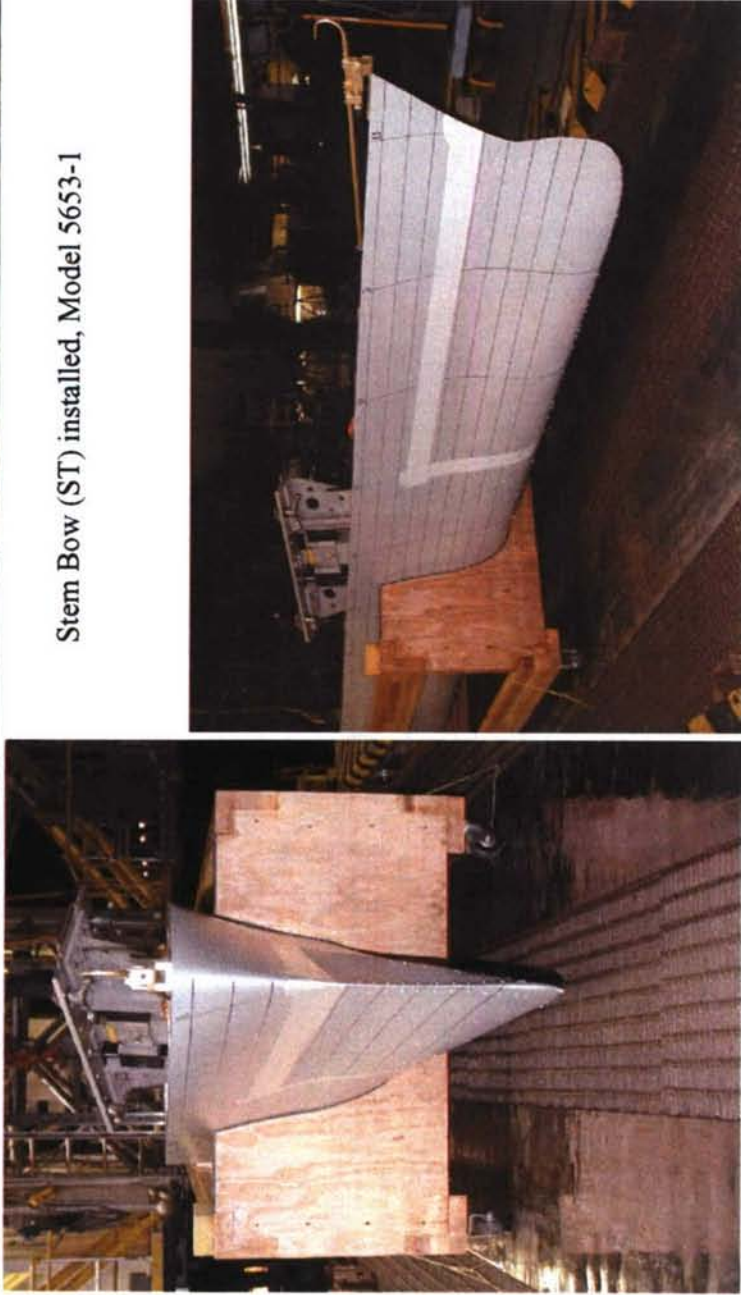


Fig. A2. JHSS BSS bow design variations, dry-dock photographs (continued)

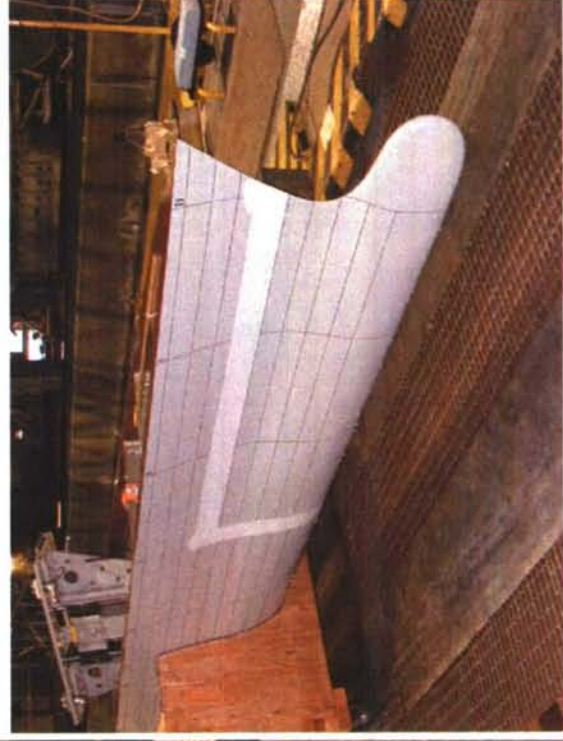
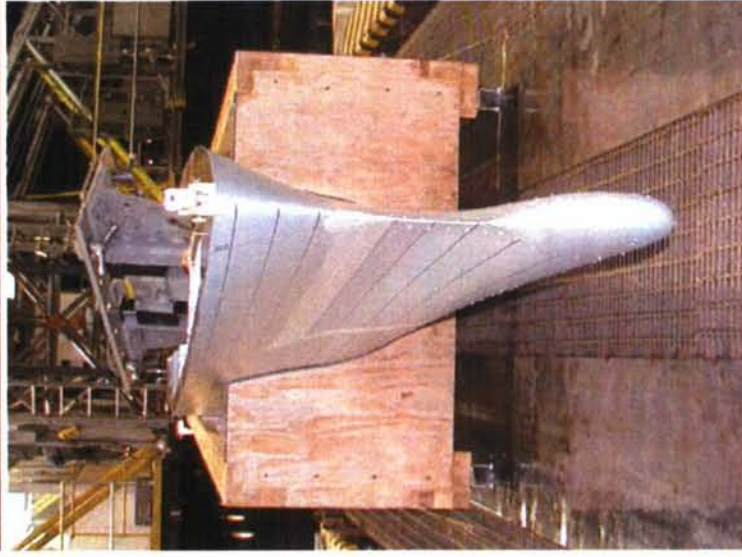
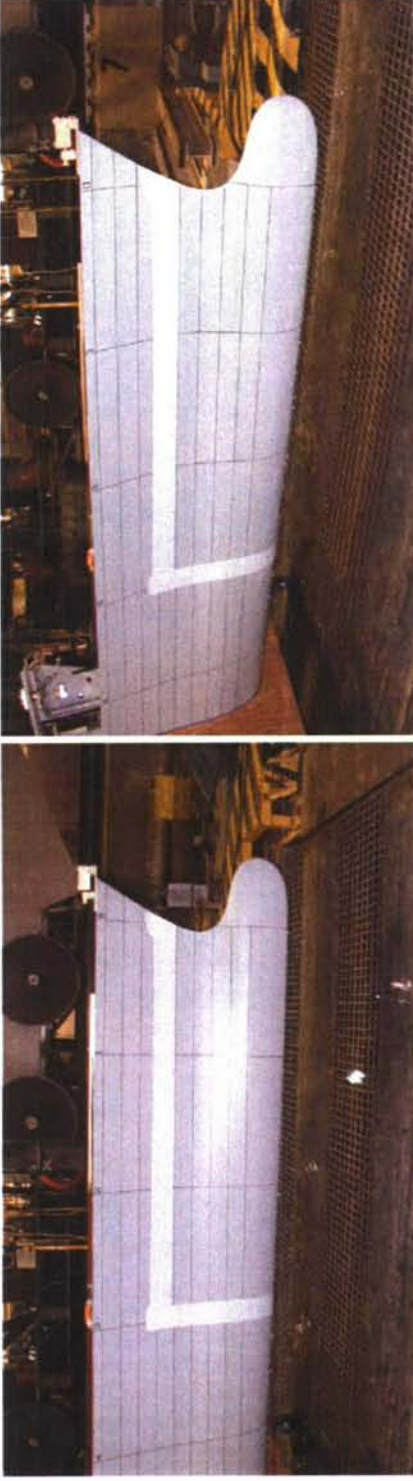


Fig. A2. JHSS BSS bow design variations, dry-dock photographs (continued)

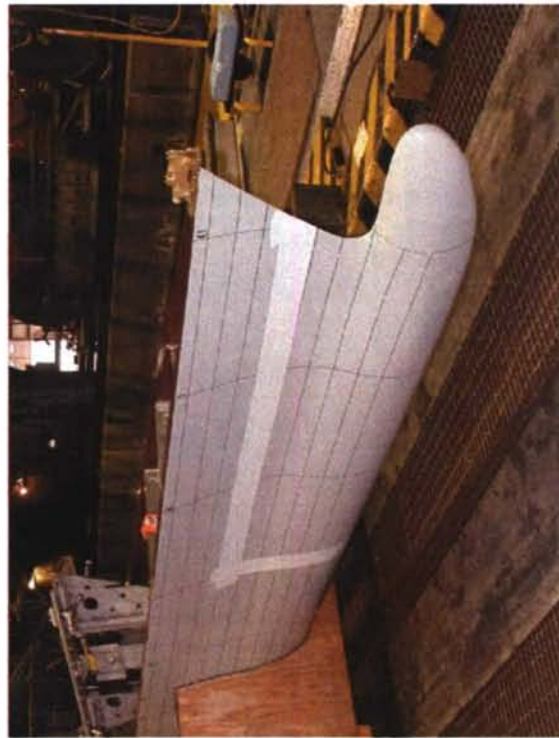
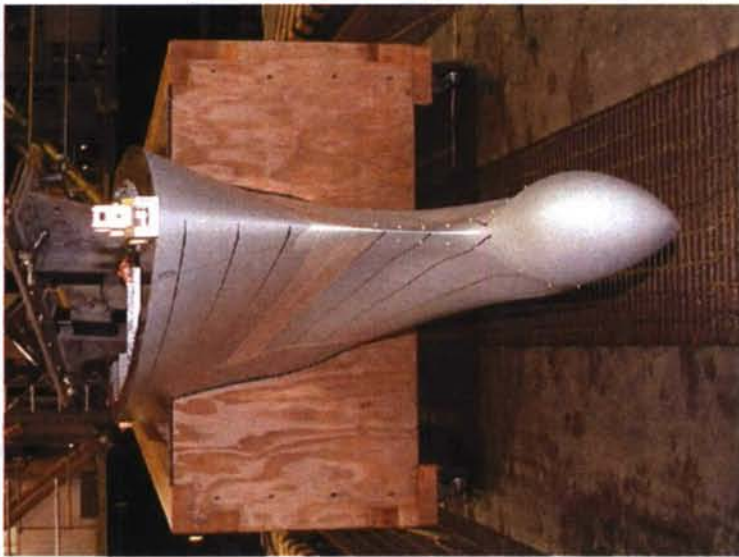
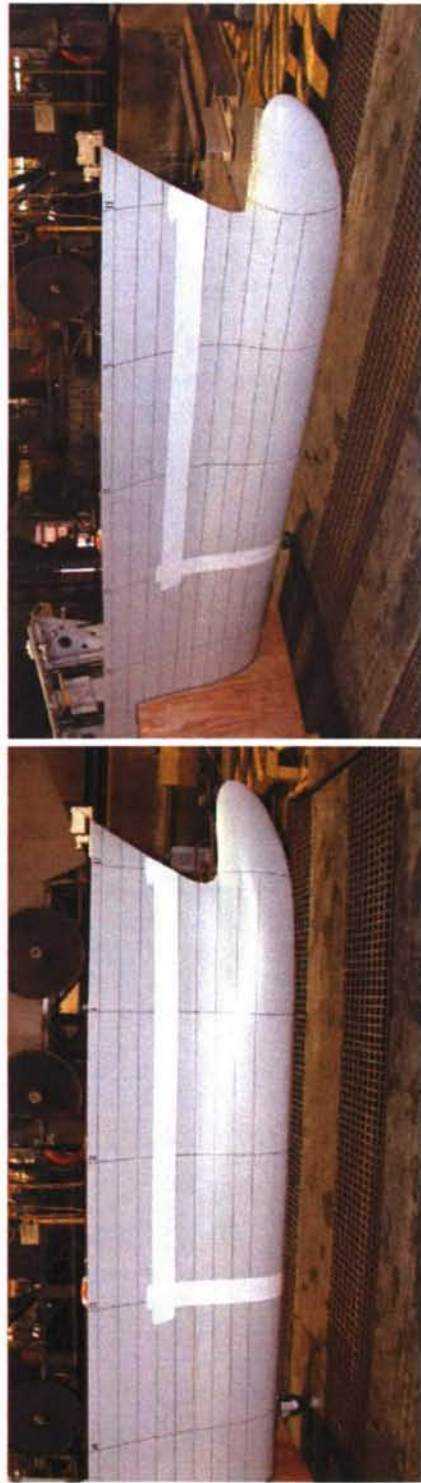


Fig. A2. JHSS BSS bow design variations, dry-dock photographs (continued)

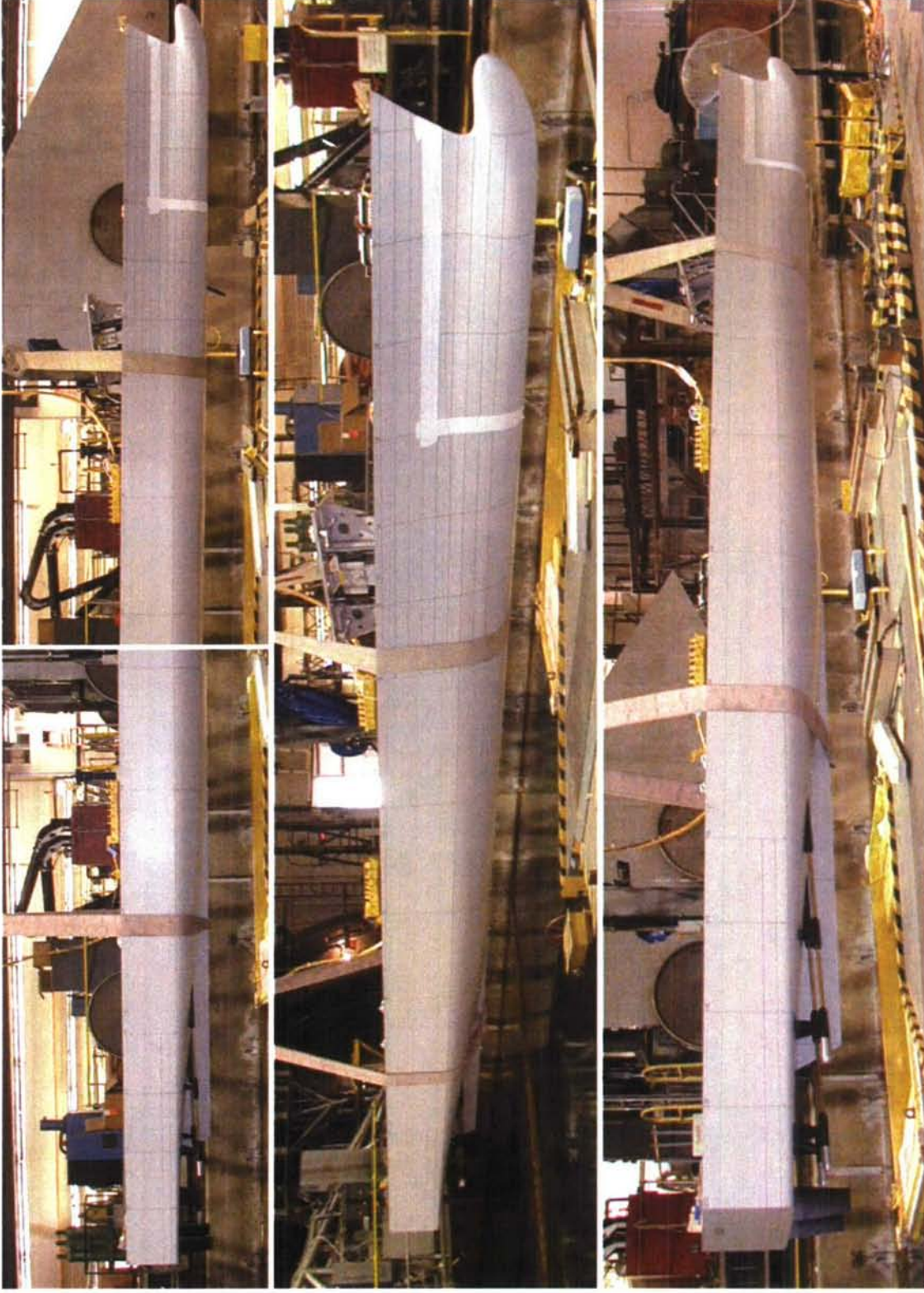


Fig. A3. JHSS BSS GB FA, dry-dock photographs

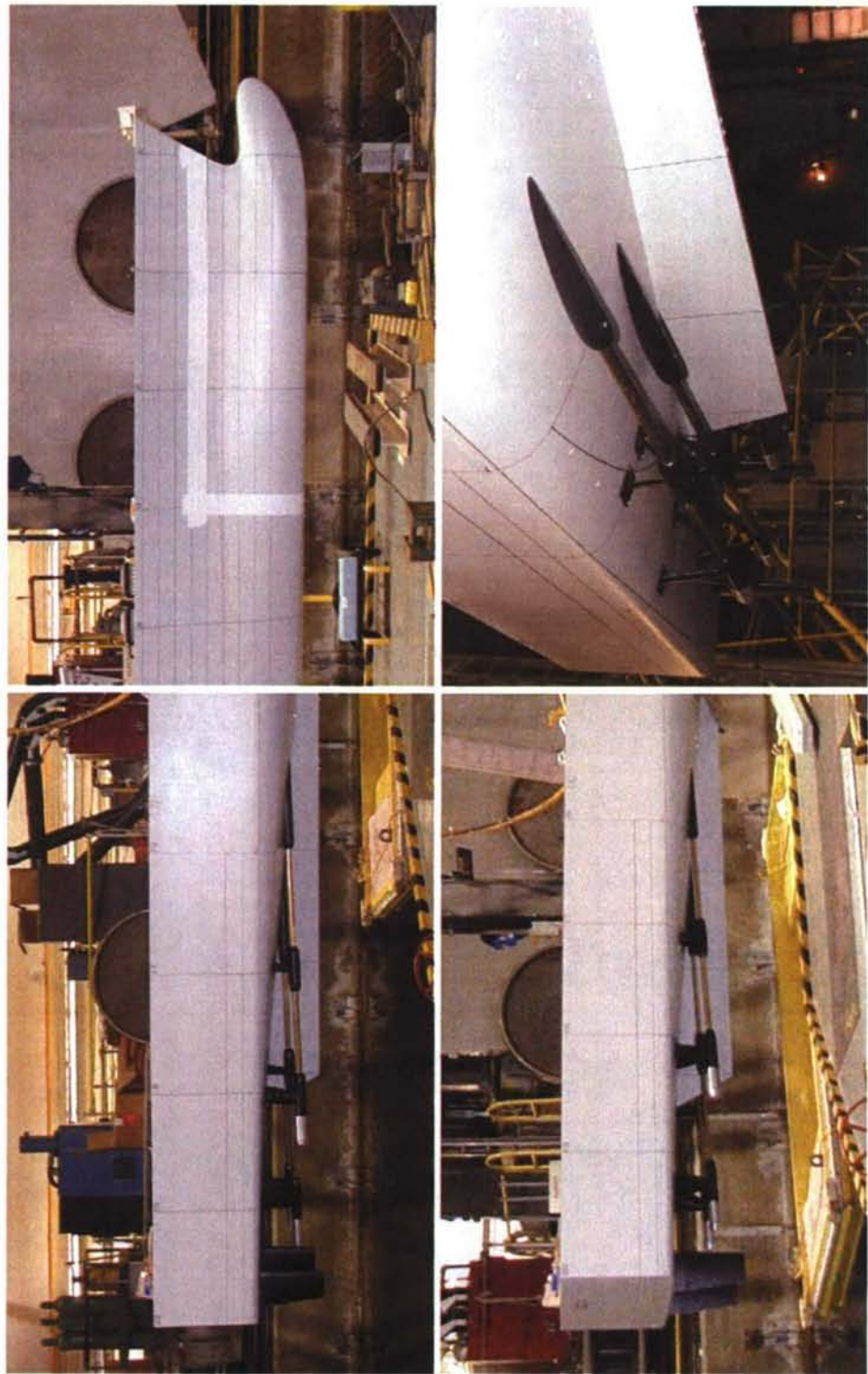


Fig. A3. JHSS BSS GB FA, dry-dock photographs (continued)

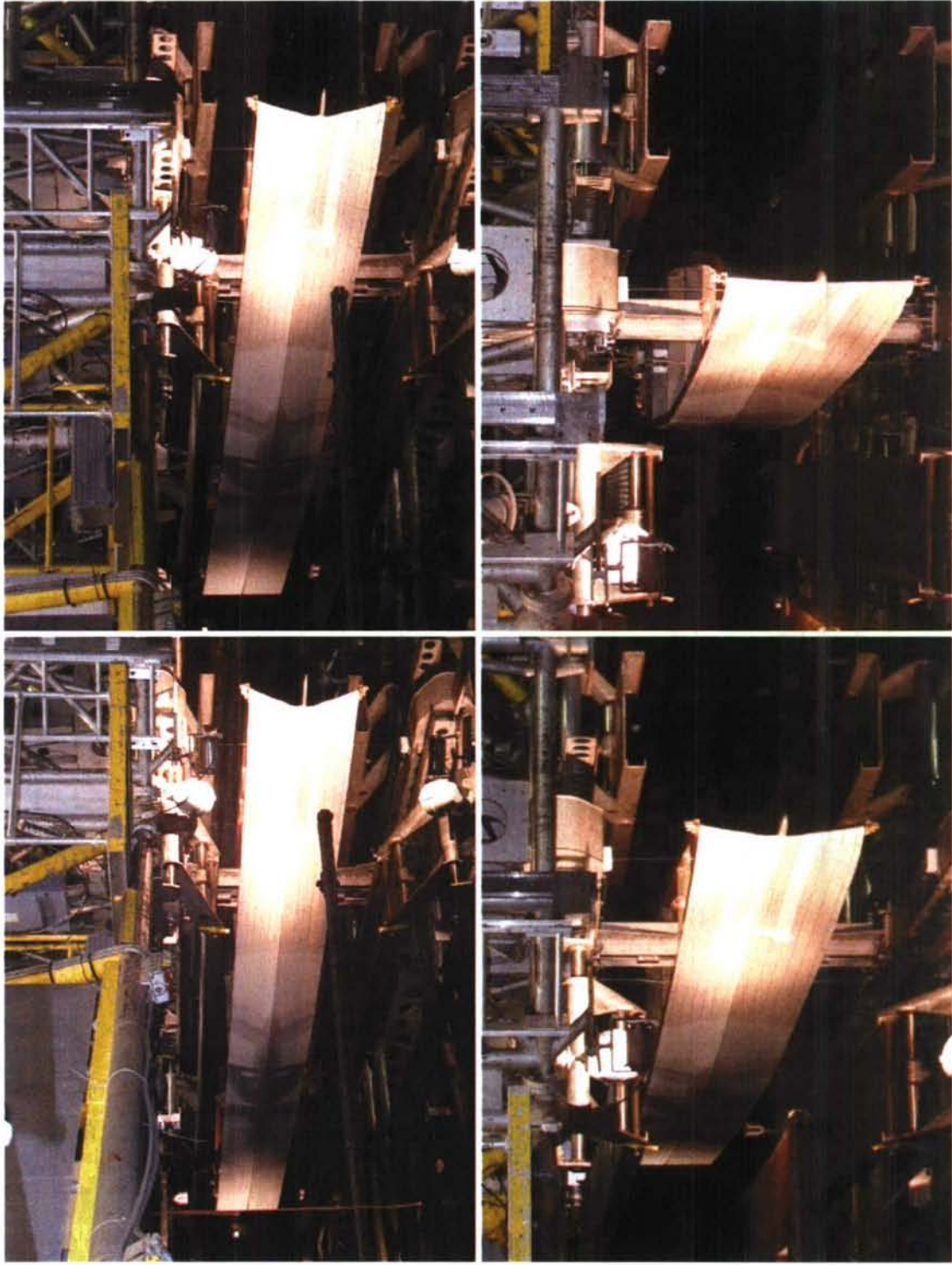


Fig. A4. JHSS BSS GB BH DES, installed under Carriage 2 for resistance tests

Table A1. Descriptions and abbreviations assigned to models, propulsion configurations, appendages, and loading conditions, for combined JHSS and Sealift R&D programs

JHSS Baseline Model	Model Number	Abbreviation
Baseline Shaft & Strut Hull, Open Propellers (full model)	5653	BSS
w/ Baseline Bulb (insert)	5653	BB
w/ Stern Bow – no bulb (insert)	5653-1	ST
w/ Elliptical Bulb (insert)	5653-2	EB
w/ Gooseneck Bulb (insert)	5653-3	GB

JHSS Alternate Model(s)	Model Number	Abbreviation
Second Bow (half model) with Selected Gooseneck Bulb	5662	2GB
w/ Axial Waterjet Stern (half model)	5662	AWJ
w/ Mixed-Flow Waterjet Stern (half model)	5662-1	MWJ
w/ Three Pod Stern, Single Centerline Shaft (half model)	5662-2	3POD
w/ Twin Pod Stern, Twin Shafts (half model)	5662-3	2POD

JHSS Propulsion Configurations	Model Number	Abbreviation
Stock Open Propulsion, Propeller Series 5233-6, 4 total	5653	SOP
Axial Waterjets, 4 total	5662	AWJ
Mixed-Flow Waterjets, 4 total	5662-1	MWJ
Three Pods, Single Centerline Propeller on Skeg	5662-2A	3PSK
Three Pods, Single Centerline Propeller on Shaft & Strut	5662-2B	3PSS
Twin Pods, Twin Propellers on Twin Skegs	5662-3A	2PSK
Twin Pods, Twin Propellers on Twin Shaft & Struts	5662-3B	2PSS

JHSS Appendages / Configurations	Abbreviation
Fully Appended (all associated appendages installed)	FA
Bare Hull (No appendages, hull penetrations sealed)	BH
Propulsion Shaftlines (4): Open Shafts, Struts, Barrels	S&S
Rudders (2): Installed Zero degrees (parallel to CL)	RUD
Stern Flap #1; 9.5ft chord, full span	SF1
Stern Flap #n; ??ft chord, ?? span	SFn
Directional Stability Fin	DSF

JHSS Loading Conditions	Long Tons	Abbreviation
Design Displacement	36491	DES
Heavy Displacement (Design +10%)	40140	HVY
Light Displacement (Design -10%)	32841	LITE

Table A2. JHSS BSS BB BH DES (Model 5653), hydrostatics

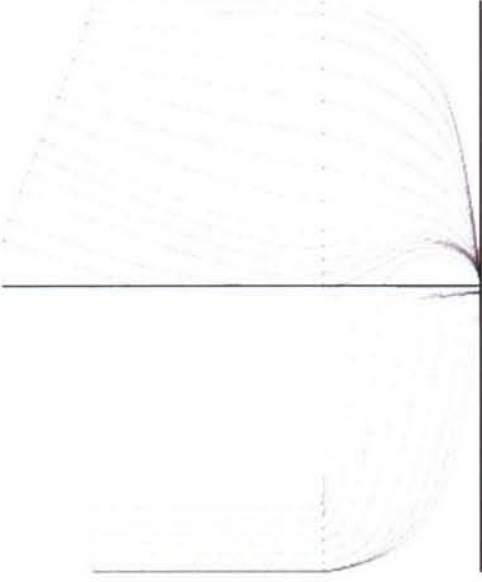
JHSS Propeller Hull Baseline Bulb 4/19/06	
	<p>PRINCIPAL DIMENSIONS</p> <p> LENGTH (LBP) = 950.51 ft (289.71 m) LENGTH (LWL) = 950.06 ft (289.58 m) BEAM (B_X) = 104.92 ft (31.98 m) DRAFT (T_X) = 28.83 ft (8.79 m) TRIM (+Bow) = 0.00 ft (0.00 m) DISPLACEMENT = 36490.5 T (37074. t) WETTED SURFACE = 105069 sqft (9761. sqm) </p>
	<p>MODEL SCALE DATA</p> <p> SCALE RATIO = 34.121 LENGTH (LBP) = 27.96 ft (8.49 m) LENGTH (LWL) = 27.84 ft (8.49 m) BEAM (B_X) = 3.08 ft (0.94 m) DRAFT (T_X) = 0.84 ft (0.26 m) DISPLACEMENT = 2001.0 lbs (0.91 t) WETTED SURFACE = 90.25 sqft (8.38 sqm) </p>
<p>NONDIMENSIONAL COEFFICIENTS</p> <p> C_B = 0.444 C_p = 0.555 C_{pF} = 0.540 C_{pA} = 0.578 C_{pE} = 0.564 C_{pR} = 0.545 C_X = 0.800 C_{WP} = 0.728 C_{WPF} = 0.531 C_{WPA} = 0.935 C_{VP} = 0.609 C_{VPF} = 0.812 C_{VPA} = 0.492 C_S = 3.018 LWL/B_X = 9.055 B_X/T_X = 3.640 A_T/A_X = 0.034 B_T/B_X = 0.750 T_T/T_X = 0.048 A_G/A_X = 0.105 L_E/LWL = 0.531 L_P/LWL = 0.000 L_P²/LWL = 0.469 FB/LWL = 0.502 FF/LWL = 0.583 100C_V = 0.149 Δ/(.01LWL)³ = 42.6 i_E = 5.99 i_R = 2.79 i_B = 2.22 </p>	

Table A3. JHSS BSS ST BH DES (Model 5653-1), hydrostatics

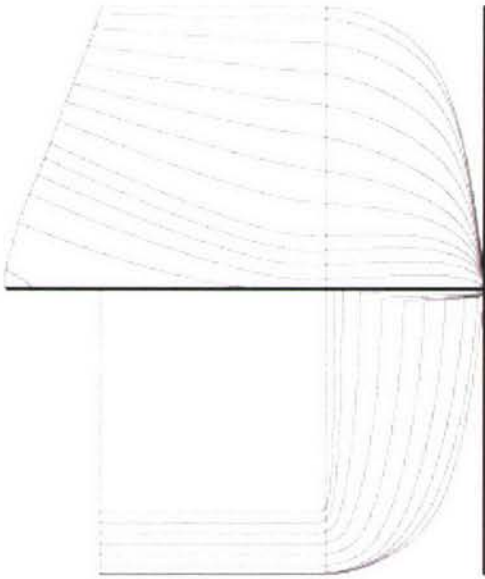
JHSS Propeller Hull NB1 04/29/06	
	<p>PRINCIPAL DIMENSIONS</p> <p> LENGTH (LBP) = 950.51 ft (289.71 m) LENGTH (LWL) = 948.95 ft (289.24 m) BEAM (B_X) = 104.96 ft (31.99 m) DRAFT (T_X) = 29.11 ft (8.87 m) TRIM (+Bow) = 0.00 ft (0.00 m) DISPLACEMENT = 36490.5 T (37074. t) WETTED SURFACE = 103623 sqft (9627. sqm) </p>
	<p>MODEL SCALE DATA</p> <p> SCALE RATIO = 34.121 LENGTH (LBP) = 27.86 ft (8.49 m) LENGTH (LWL) = 27.81 ft (8.48 m) BEAM (B_X) = 3.08 ft (0.94 m) DRAFT (T_X) = 0.85 ft (0.26 m) DISPLACEMENT = 2001.0 lbs (0.91 t) WETTED SURFACE = 89.01 sqft (8.27 sqm) </p>
<p>NONDIMENSIONAL COEFFICIENTS</p> <p> C_B = 0.440 C_P = 0.550 C_{PF} = 0.527 C_{PA} = 0.579 C_{PE} = 0.551 C_{PR} = 0.548 C_X = 0.800 C_{WP} = 0.729 C_{WPF} = 0.531 C_{WPA} = 0.936 C_{VP} = 0.604 C_{VPF} = 0.794 C_{VPA} = 0.405 C_S = 2.978 LWL/B_X = 9.041 B_X/T_X = 3.606 A_T/A_X = 0.041 B_T/B_X = 0.760 T_T/T_X = 0.053 A_B/A_X = 0.000 L_F/LWL = 0.531 L_P/LWL = 0.000 L_R/LWL = 0.469 FB/LWL = 0.510 FF/LWL = 0.594 $100C_V$ = 0.149 $\Delta/(0.01LWL)^3$ = 42.7 I_E = 5.45 I_R = 2.70 I_B = 2.22 </p>	

Table A4. JHSS BSS EB BH DES (Model 5653-2), hydrostatics

JHSS Propeller Hull Elliptical Bulb 05/11/2006

PRINCIPAL DIMENSIONS

LENGTH (LBP)	=	950.51 ft (289.71 m)
LENGTH (LWL)	=	949.42 ft (289.38 m)
BEAM (B _X)	=	104.93 ft (31.98 m)
DRAFT (T _X)	=	28.93 ft (8.82 m)
TRIM (+Bow)	=	0.00 ft (0.00 m)
DISPLACEMENT	=	38490.5 T (37074. t)
WETTED SURFACE	=	105217 sqft (9775. sqm)

NONDIMENSIONAL COEFFICIENTS

C _B	=	0.443	C _{VP}	=	0.607	L _E /LWL	=	0.531
C _P	=	0.554	C _{VPF}	=	0.807	L _P /LWL	=	0.000
C _{PF}	=	0.537	C _{VPA}	=	0.493	L _R /LWL	=	0.469
C _{PA}	=	0.576	C _S	=	3.023	FB/LWL	=	0.504
C _{PE}	=	0.561	LWL/B _X	=	9.049	FF/LWL	=	0.593
C _{PR}	=	0.545	B _X /T _X	=	3.627	100C _V	=	0.149
C _X	=	0.799	A _T /A _X	=	0.036	Δ/(.01LWL) ³	=	42.6
C _{WP}	=	0.729	B _T /B _X	=	0.753	I _E	=	6.05
C _{WPF}	=	0.532	T _T /T _X	=	0.047	I _R	=	2.76
C _{WPA}	=	0.935	A _B /A _X	=	0.090	I _B	=	2.22

MODEL SCALE DATA

SCALE RATIO	=	34.121
LENGTH (LBP)	=	27.86 ft (8.49 m)
LENGTH (LWL)	=	27.83 ft (8.48 m)
BEAM (B _X)	=	3.08 ft (0.94 m)
DRAFT (T _X)	=	0.85 ft (0.26 m)
DISPLACEMENT	=	2001.0 lbs (0.91 t)
WETTED SURFACE	=	90.38 sqft (8.40 sqm)

Table A5. JHSS BSS GB BH DES (Model 5653-3), hydrostatics

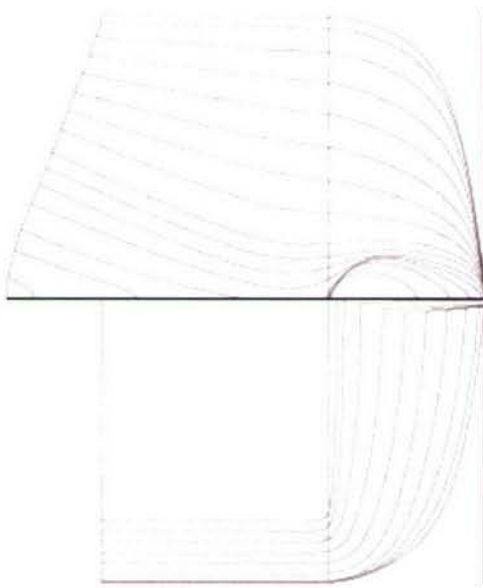
JHSS Propeller Hull With Gooseneck Bulb 04/19/2006		
	<p>PRINCIPAL DIMENSIONS</p> <p>LENGTH (LBP) = 980.03 ft (298.71 m) LENGTH (LWL) = 977.89 ft (298.06 m) BEAM (B_X) = 104.87 ft (31.97 m) DRAFT (T_X) = 28.82 ft (8.78 m) TRIM (+Bow) = 0.00 ft (0.00 m) DISPLACEMENT = 36490.5 T (37074. t) WETTED SURFACE = 105221 sqft (9775. sqm)</p>	
<p>NONDIMENSIONAL COEFFICIENTS</p> <p>C_B = 0.432 C_P = 0.538 C_{PF} = 0.499 C_{PA} = 0.587 C_{PE} = 0.522 C_{PR} = 0.556 C_X = 0.802 C_{WP} = 0.710 C_{WPF} = 0.495 C_{WPA} = 0.942 C_{VP} = 0.608 C_{VPF} = 0.812 C_{VPA} = 0.501 C_S = 2.979 LWL/B_X = 9.324 B_X/T_X = 3.639 A_T/A_X = 0.032 B_T/B_X = 0.746 T_T/T_X = 0.044 A_B/A_X = 0.113 L_E/LWL = 0.529 L_P/LWL = 0.000 L_R/LWL = 0.471 FB/LWL = 0.486 FF/LWL = 0.574 100C_∇ = 0.136 Δ/(L₀₁LWL)³ = 39.0 i_E = 4.25 i_R = 2.99 i_B = 2.89</p>	<p>MODEL SCALE DATA</p> <p>SCALE RATIO = 34.121 LENGTH (LBP) = 28.72 ft (8.75 m) LENGTH (LWL) = 28.66 ft (8.74 m) BEAM (B_X) = 3.07 ft (0.94 m) DRAFT (T_X) = 0.84 ft (0.26 m) DISPLACEMENT = 2001.0 lbs (0.91 t) WETTED SURFACE = 90.38 sqft (8.40 sqm)</p>	

Table A6. JHSS BSS BB BH&FA DES (Model 5653), ship/model test parameters

Baseline S&S Hull (BSS) Baseline Bulb (BB)	Design (DES) 36491 tons		Heavy (HVV) +10% 40140 tons		Light (LITE) -10% 32841 tons	
Model 5653	SHIP	MODEL	SHIP	MODEL		
MODEL SCALE RATIO	-	34.121	-	34.121	-	34.121
LOA (ft)	977.5	28.648	977.5	28.648	977.5	28.648
LBP (ft)	950.5	27.857	950.5	27.857	950.5	27.857
LWL (ft)	950.1	27.844	949.1	27.816	946.6	27.742
WET SURF HULL(sq ft)	105069	90.247	108594	93.274	98649	84.732
WET SURF APP(sq ft)	1623	1.394	0	0.000	0	0.000
TOTAL WET SURF(sq ft)	106692	91.641	108594	93.274	98649	84.732
DISPLACEMENT (ton, lbs)	36491	2000	40140	2200	32841	1800
BOW DRAFT @FP (ft)	28.83	0.845	30.58	0.896	27.04	0.792
STERN DRAFT @AP (ft)	28.83	0.845	30.58	0.896	27.04	0.792
SHIP TRIM (+ft bow up)	0.00	0.000	0.00	0.000	0.00	0.000
TRIM ANGLE (degrees)	0.00		0.00		0.00	
BEAM (ft)	104.9	3.075	105.1	3.079	104.5	3.064
TEMP (F)	59	70	59	70	59	70
RHO	1.9905	1.9362	1.9905	1.9362	1.9905	1.9362
NU	1.2817	1.0552	1.2817	1.0552	1.2817	1.0552
Bow Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook fwd of FP (ft)	19.9	0.583	0.0	0.000	0.0	0.000
Stern Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook aft of AP (ft)	0.0	0.000	0.0	0.000	0.0	0.000
BOW HOOK SETTING (ft)		1.237		1.186		1.289
Hook if at FP (ft)	-	1.237	-	1.186	-	1.289
Hook if at AP (ft)	-	1.237	-	1.186	-	1.289
STERN HOOK SETTING (ft)		1.237		1.186		1.289
PROP DIA (ft, in)	21.33	7.500	21.33	7.500	21.33	7.500
PROP ROTATION	OTBD	OTBD	OTBD	OTBD	OTBD	OTBD
SPEED RANGE, min (kts)	15.0	2.57	15.0	2.57	15.0	2.57
Design Speed (kts)	36.0	6.16	36.0	6.16	36.0	6.16
max (kts)	45.0	7.70	45.0	7.70	45.0	7.70
MODEL DISP desired (lbs)		2000		2200		1800
DISP actual (ton, lbs)	36485	2000	40134	2200	32837	1800
MODEL WEIGHT (lbs)	-	905	-	905	-	905
Floating Platform (lbs)	-	45	-	45	-	45
BALLAST required (lbs)	-	1050	-	1250	-	850
delta DISP (ton, lbs)				+200 +10.0%		-200 -10.0%
APPENDAGES, ws (sqft)	1623.5	1.394	0.0	0.000	0.0	0.000
*Rudders (2), redesigned	1623.5	1.394	0.0	0.000	0.0	0.000

*Calculated from Rhino surface file

Table A7. JHSS BSS ST BH DES (Model 5653-1), ship/model test parameters

Baseline S&S Hull (BSS) Stem Bow (ST)	Design (DES) 36491 tons		Heavy (HVY) +10% 40140 tons		Light (LITE) -10% 32841 tons	
Model 5653-1	SHIP	MODEL	SHIP	MODEL		
MODEL SCALE RATIO	-	34.121	-	34.121	-	34.121
LOA (ft)	977.5	28.648	977.5	28.648	977.5	28.648
LBP (ft)	950.5	27.857	950.5	27.857	950.5	27.857
LWL (ft)	949.0	27.811	948.4	27.795	944.7	27.686
WET SURF HULL(sq ft)	103623	89.005	107122	92.010	97488	83.735
WET SURF APP(sq ft)	0	0.000	0	0.000	0	0.000
TOTAL WET SURF(sq ft)	103623	89.005	107122	92.010	97488	83.735
DISPLACEMENT (ton, lbs)	36491	2000	40140	2200	32841	1800
BOW DRAFT @FP (ft)	29.11	0.853	30.86	0.904	27.33	0.801
STERN DRAFT @AP (ft)	29.11	0.853	30.86	0.904	27.33	0.801
SHIP TRIM (+ft bow up)	0.00	0.000	0.00	0.000	0.00	0.000
TRIM ANGLE (degrees)	0.00		0.00		0.00	
BEAM (ft)	105.0	3.076	105.1	3.079	104.6	3.066
TEMP (F)	59	70	59	70	59	70
RHO	1.9905	1.9362	1.9905	1.9362	1.9905	1.9362
NU	1.2817	1.0552	1.2817	1.0552	1.2817	1.0552
Bow Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook fwd of FP (ft)	19.9	0.583	0.0	0.000	0.0	0.000
Stern Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook aft of AP (ft)	0.0	0.000	0.0	0.000	0.0	0.000
BOW HOOK SETTING (ft)		1.229		1.178		1.281
Hook if at FP (ft)	-	1.229	-	1.178	-	1.281
Hook if at AP (ft)	-	1.229	-	1.178	-	1.281
STERN HOOK SETTING (ft)		1.229		1.178		1.281
PROP DIA (ft, in)	21.33	7.500	21.33	7.500	21.33	7.500
PROP ROTATION	OTBD	OTBD	OTBD	OTBD	OTBD	OTBD
SPEED RANGE, min (kts)	15.0	2.57	15.0	2.57	15.0	2.57
Design Speed (kts)	36.0	6.16	36.0	6.16	36.0	6.16
max (kts)	45.0	7.70	45.0	7.70	45.0	7.70
MODEL DISP desired (lbs)		2000		2200		1800
DISP actual (ton, lbs)	36485	2000	40134	2200	32837	1800
MODEL WEIGHT (lbs)	-	904	-	904	-	904
Floating Platform (lbs)	-	45	-	45	-	45
BALLAST required (lbs)	-	1051	-	1251	-	851
delta DISP (ton, lbs)				+200 +10.0%		-200 -10.0%
APPENDAGES, ws (sqft)	0.0	0.000	0.0	0.000	0.0	0.000
	0.0	0.000	0.0	0.000	0.0	0.000

Table A8. JHSS BSS EB BH DES (Model 5653-2), ship/model test parameters

Baseline S&S Hull (BSS) Elliptical Bulb (EB)	Design (DES)		Heavy (HVV)		Light (LITE)	
	36491 tons		+10% 40140 tons		-10% 32841 tons	
Model 5653-2	SHIP	MODEL	SHIP	MODEL		
MODEL SCALE RATIO	-	34.121	-	34.121	-	34.121
LOA (ft)	977.5	28.648	977.5	28.648	977.5	28.648
LBP (ft)	950.5	27.857	950.5	27.857	950.5	27.857
LWL (ft)	949.4	27.825	948.6	27.801	946.0	27.725
WET SURF HULL(sq ft)	105217	90.374	108734	93.395	98895	84.944
WET SURF APP(sq ft)	0	0.000	0	0.000	0	0.000
TOTAL WET SURF(sq ft)	105217	90.374	108734	93.395	98895	84.944
DISPLACEMENT (ton, lbs)	36491	2000	40140	2200	32841	1800
BOW DRAFT @FP (ft)	28.93	0.848	30.68	0.899	27.15	0.796
STERN DRAFT @AP (ft)	28.93	0.848	30.68	0.899	27.15	0.796
SHIP TRIM (+ft bow up)	0.00	0.000	0.00	0.000	0.00	0.000
TRIM ANGLE (degrees)	0.00		0.00		0.00	
BEAM (ft)	105.0	3.076	105.1	3.079	104.6	3.066
TEMP (F)	59	70	59	70	59	70
RHO	1.9905	1.9362	1.9905	1.9362	1.9905	1.9362
NU	1.2817	1.0552	1.2817	1.0552	1.2817	1.0552
Bow Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook fwd of FP (ft)	19.9	0.583	0.0	0.000	0.0	0.000
Stern Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook aft of AP (ft)	0.0	0.000	0.0	0.000	0.0	0.000
BOW HOOK SETTING (ft)		1.234		1.183		1.286
Hook if at FP (ft)	-	1.234	-	1.183	-	1.286
Hook if at AP (ft)	-	1.234	-	1.183	-	1.286
STERN HOOK SETTING (ft)		1.234		1.183		1.286
PROP DIA (ft, in)	21.33	7.500	21.33	7.500	21.33	7.500
PROP ROTATION	OTBD	OTBD	OTBD	OTBD	OTBD	OTBD
SPEED RANGE, min (kts)	15.0	2.57	15.0	2.57	15.0	2.57
Design Speed (kts)	36.0	6.16	36.0	6.16	36.0	6.16
max (kts)	45.0	7.70	45.0	7.70	45.0	7.70
MODEL DISP desired (lbs)		2000		2200		1800
DISP actual (ton, lbs)	36485	2000	40134	2200	32837	1800
MODEL WEIGHT (lbs)	-	917	-	917	-	917
Floating Platform (lbs)	-	45	-	45	-	45
BALLAST required (lbs)	-	1038	-	1238	-	838
delta DISP (ton, lbs)				+200 +10.0%		-200 -10.0%
APPENDAGES, ws (sqft)	0.0	0.000	0.0	0.000	0.0	0.000
*Rudders (2), redesigned	0.0	0.000	0.0	0.000	0.0	0.000

Table A9. JHSS BSS GB BH&FA DES (Model 5653-3), ship/model test parameters

Baseline S&S Hull (BSS) Gooseneck Bulb (GB)	Design (DES)		Heavy (HVY) +10%		Light (LITE) -10%	
	36491 tons		40140 tons		32841 tons	
Model 5653-3	SHIP	MODEL	SHIP	MODEL		
MODEL SCALE RATIO	-	34.121	-	34.121	-	34.121
LOA (ft)	977.5	28.648	977.5	28.648	977.5	28.648
LBP (ft)	950.5	27.857	950.5	27.857	950.5	27.857
LWL (ft)	977.9	28.659	947.9	27.781	976.4	28.616
WET SURF HULL(sq ft)	105221	90.377	108840	93.486	98550	84.647
WET SURF APP(sq ft)	1624	1.394	0	0.000	0	0.000
TOTAL WET SURF(sq ft)	106845	91.772	108840	93.486	98550	84.647
DISPLACEMENT (ton, lbs)	36491	2000	40140	2200	32841	1800
BOW DRAFT @FP (ft)	28.82	0.845	30.57	0.896	27.04	0.792
STERN DRAFT @AP (ft)	28.82	0.845	30.57	0.896	27.04	0.792
SHIP TRIM (+ft bow up)	0.00	0.000	0.00	0.000	0.00	0.000
TRIM ANGLE (degrees)	0.00		0.00		0.00	
BEAM (ft)	105.0	3.076	105.1	3.079	104.6	3.066
TEMP (F)	59	70	59	70	59	70
RHO	1.9905	1.9362	1.9905	1.9362	1.9905	1.9362
NU	1.2817	1.0552	1.2817	1.0552	1.2817	1.0552
Bow Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook fwd of FP (ft)	19.9	0.583	0.0	0.000	0.0	0.000
Stern Deck/Keel (ft)	71.0	2.082	71.0	2.082	71.0	2.082
Pos of Hook aft of AP (ft)	0.0	0.000	0.0	0.000	0.0	0.000
BOW HOOK SETTING (ft)		1.237		1.186		1.289
Hook if at FP (ft)	-	1.237	-	1.186	-	1.289
Hook if at AP (ft)	-	1.237	-	1.186	-	1.289
STERN HOOK SETTING (ft)		1.237		1.186		1.289
PROP DIA (ft, in)	21.33	7.500	21.33	7.500	21.33	7.500
PROP ROTATION	OTBD	OTBD	OTBD	OTBD	OTBD	OTBD
SPEED RANGE, min (kts)	15.0	2.57	15.0	2.57	15.0	2.57
Design Speed (kts)	36.0	6.16	36.0	6.16	36.0	6.16
max (kts)	45.0	7.70	45.0	7.70	45.0	7.70
MODEL DISP desired (lbs)		2000		2200		1800
DISP actual (ton, lbs)	36485	2000	40134	2200	32837	1800
MODEL WEIGHT (lbs)	-	919	-	919	-	919
Floating Platform (lbs)	-	45	-	45	-	45
BALLAST required (lbs)	-	1036	-	1236	-	836
delta DISP (ton, lbs)				+200 +10.0%		-200 -10.0%
APPENDAGES, ws (sqft)	1623.5	1.394	0.0	0.000	0.0	0.000
*Rudders (2), redesigned	1623.5	1.394	0.0	0.000	0.0	0.000

*Calculated from Rhino surface file

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APPENDIX B

SERIES 1 - RESISTANCE TESTS

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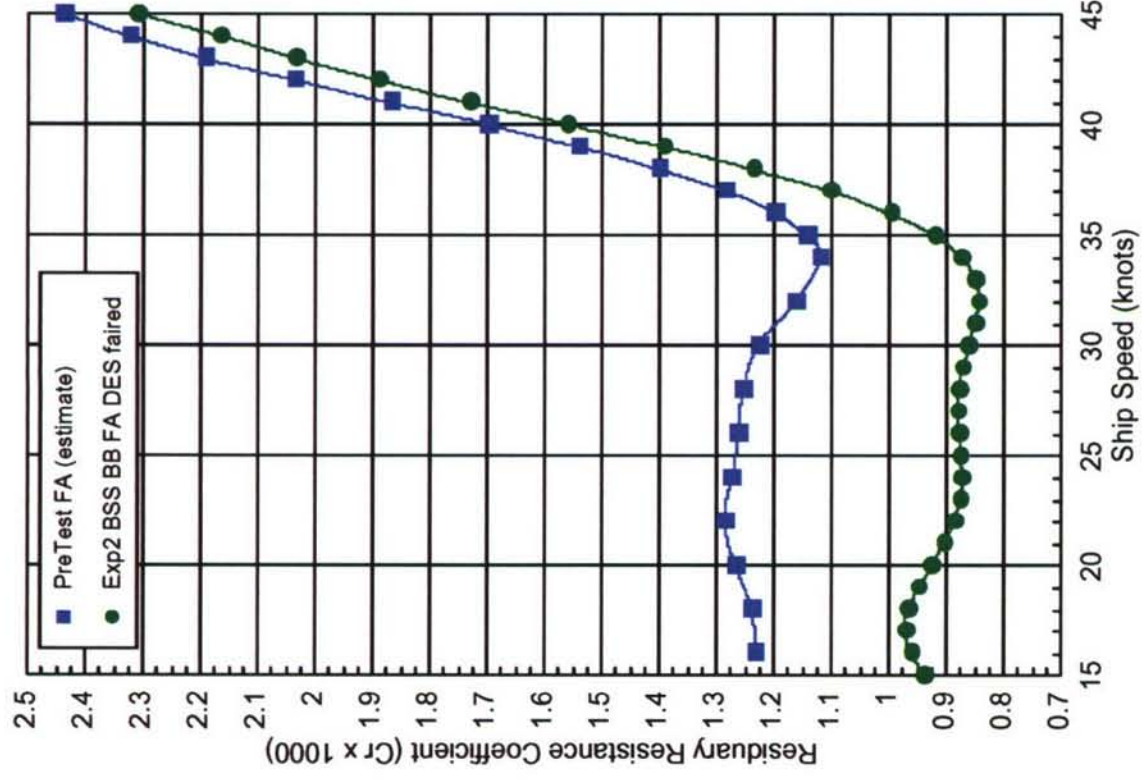
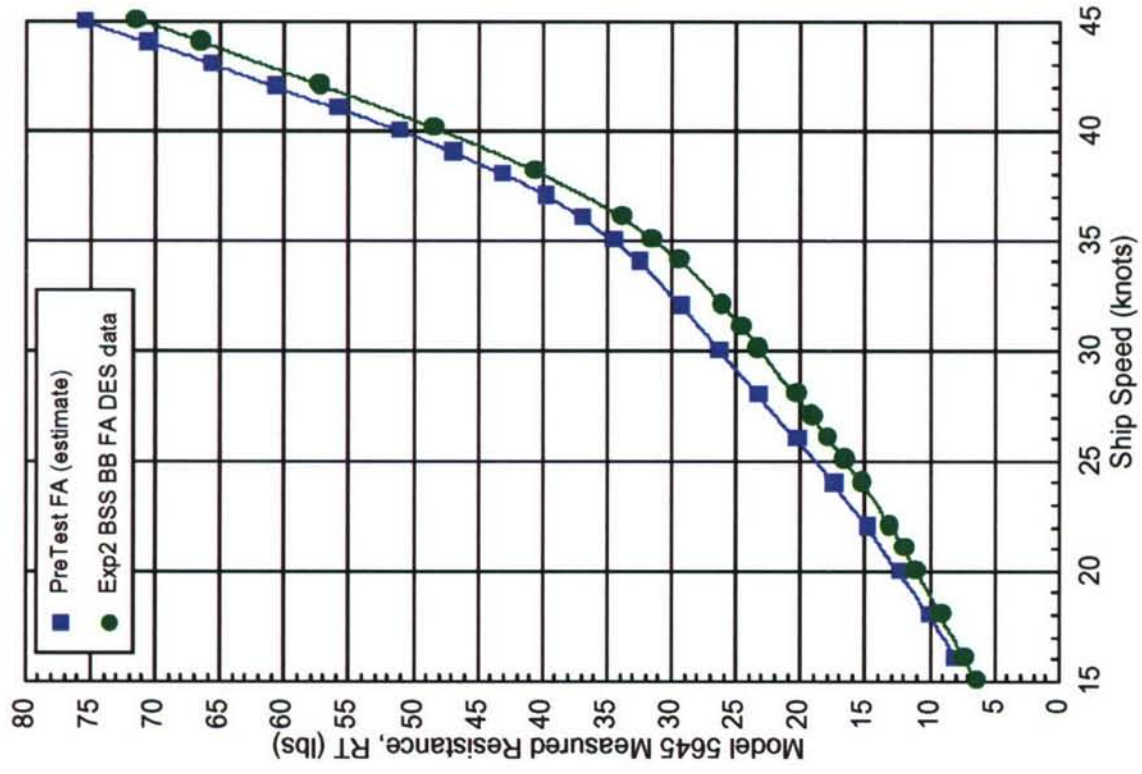


Fig B1. JHSS: BSS, BB, FA, DES, comparisons of Exp2 vs. pre-test estimates

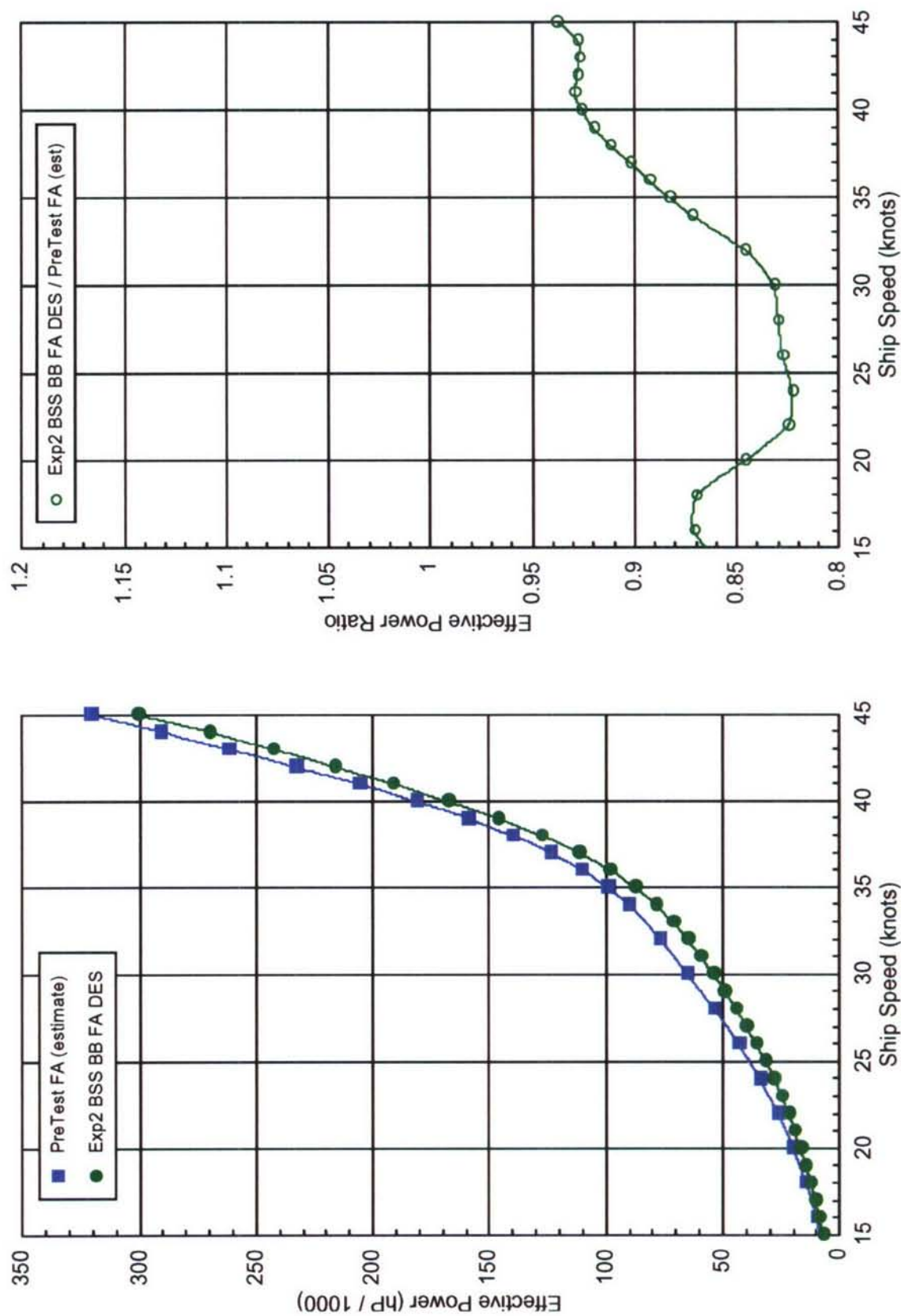


Fig B1. JHSS: BSS, BB, FA, DES, comparisons of Exp2 vs. pre-test estimates (continued)

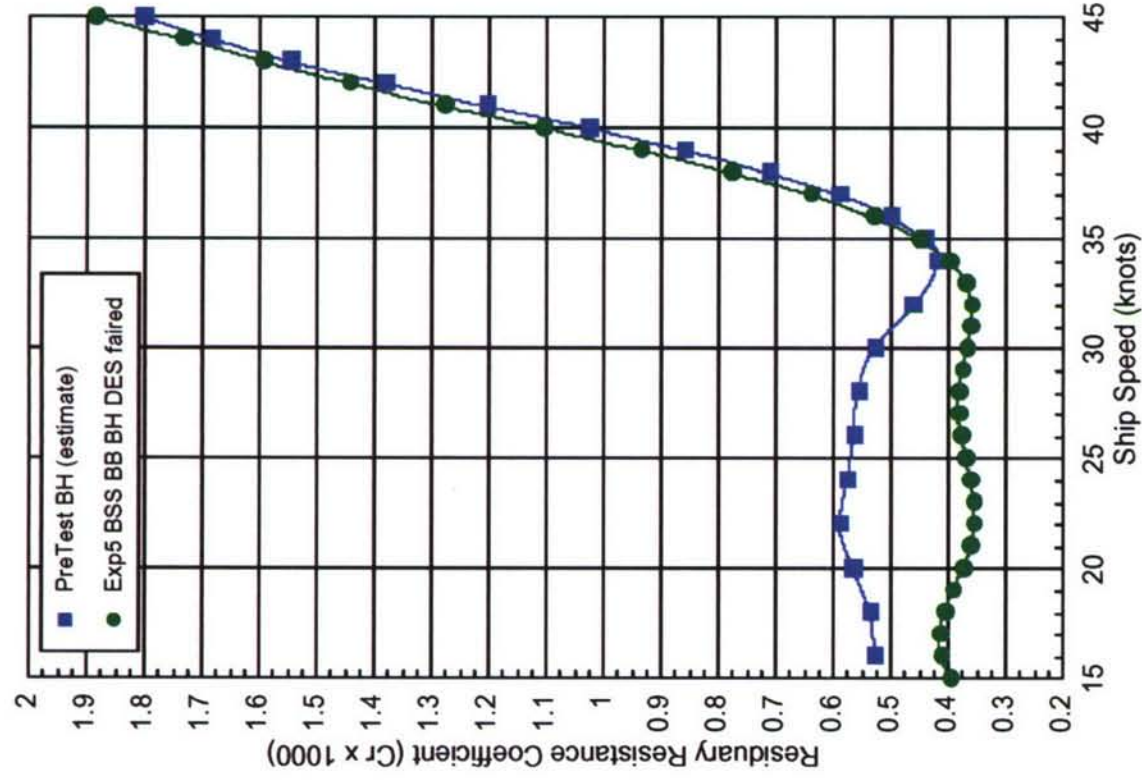
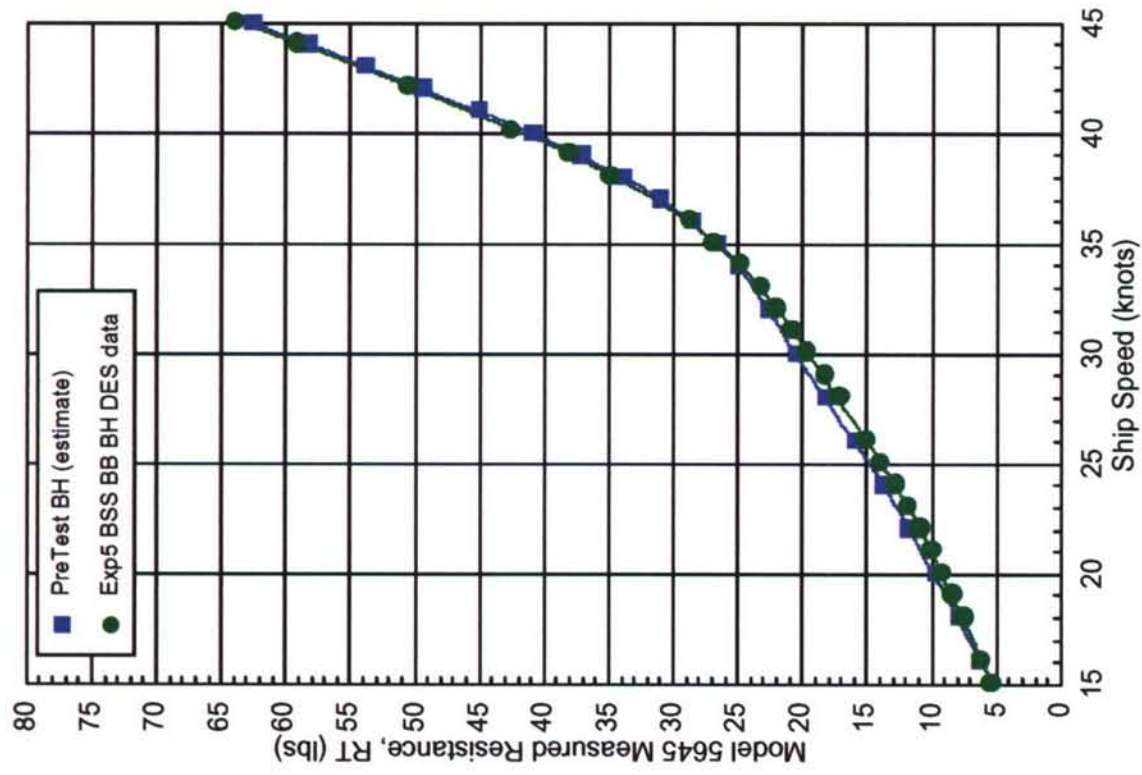


Fig B2. JHSS: BSS, BB, BH, DES, comparisons of Exp5 vs. pre-test estimates

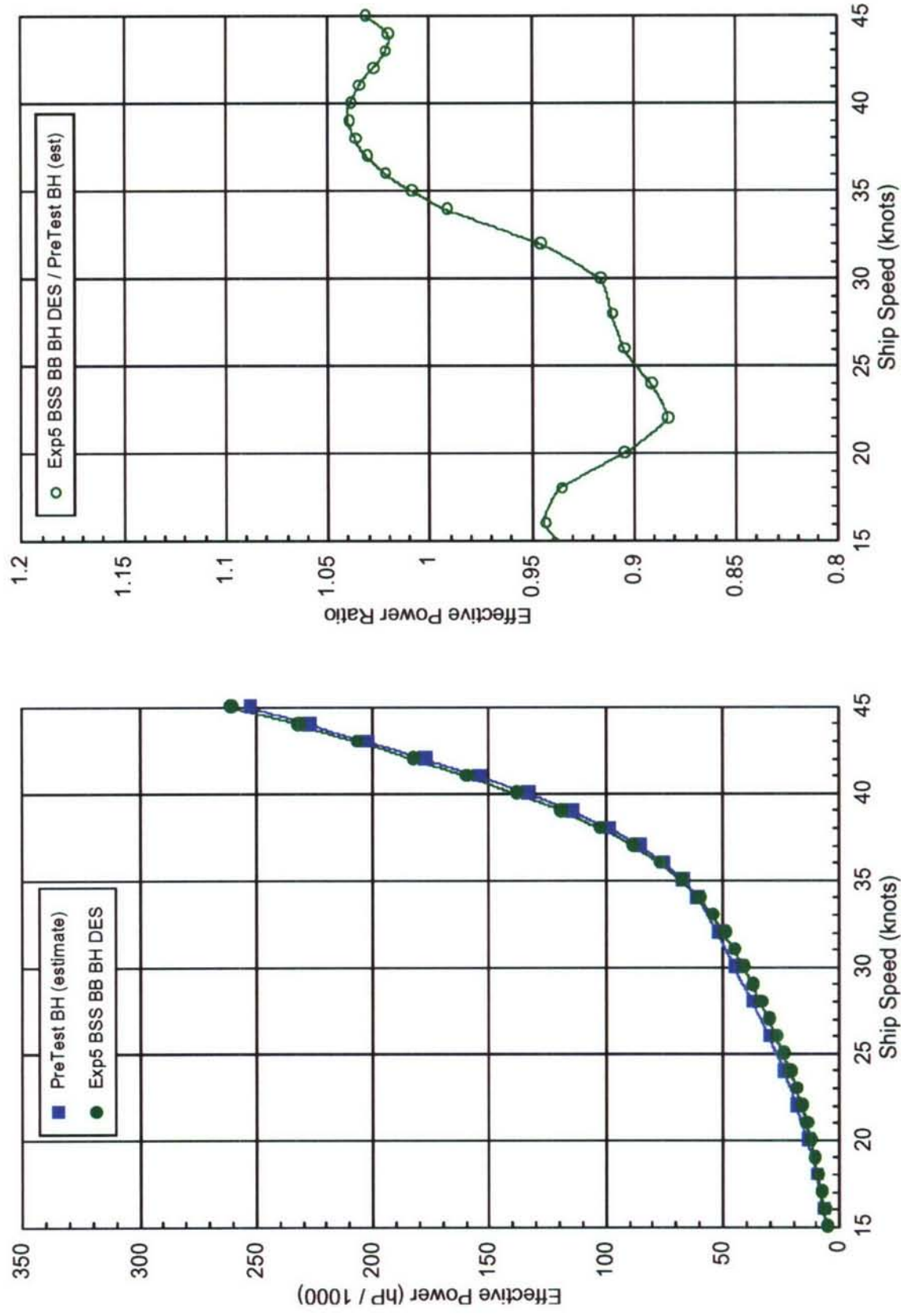


Fig B2. JHSS: BSS, BB, BH, DES, comparisons of Exp5 vs. pre-test estimates (continued)

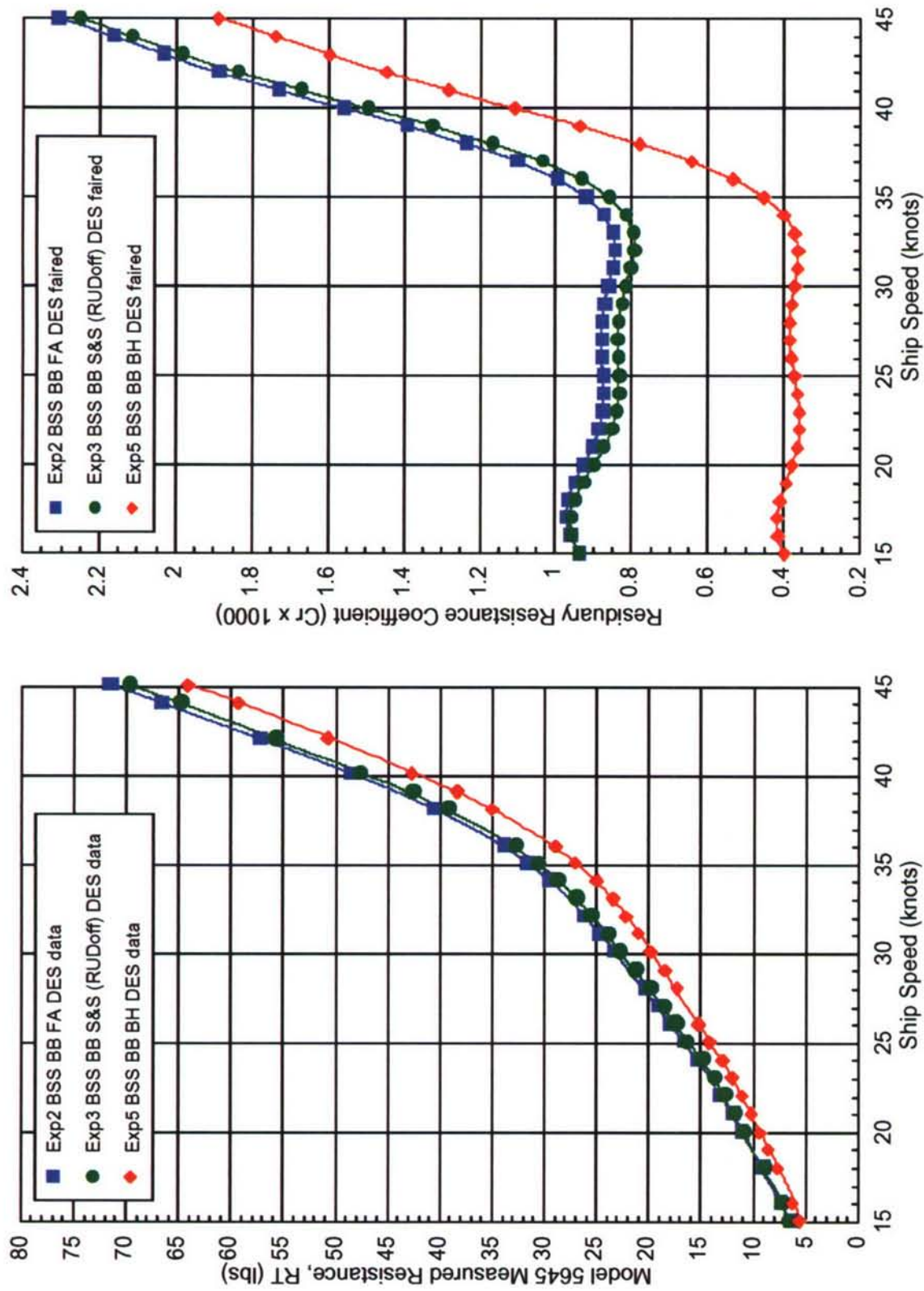


Fig B3. JHSS: BSS, BB, appendage variations, DES, PE test comparisons

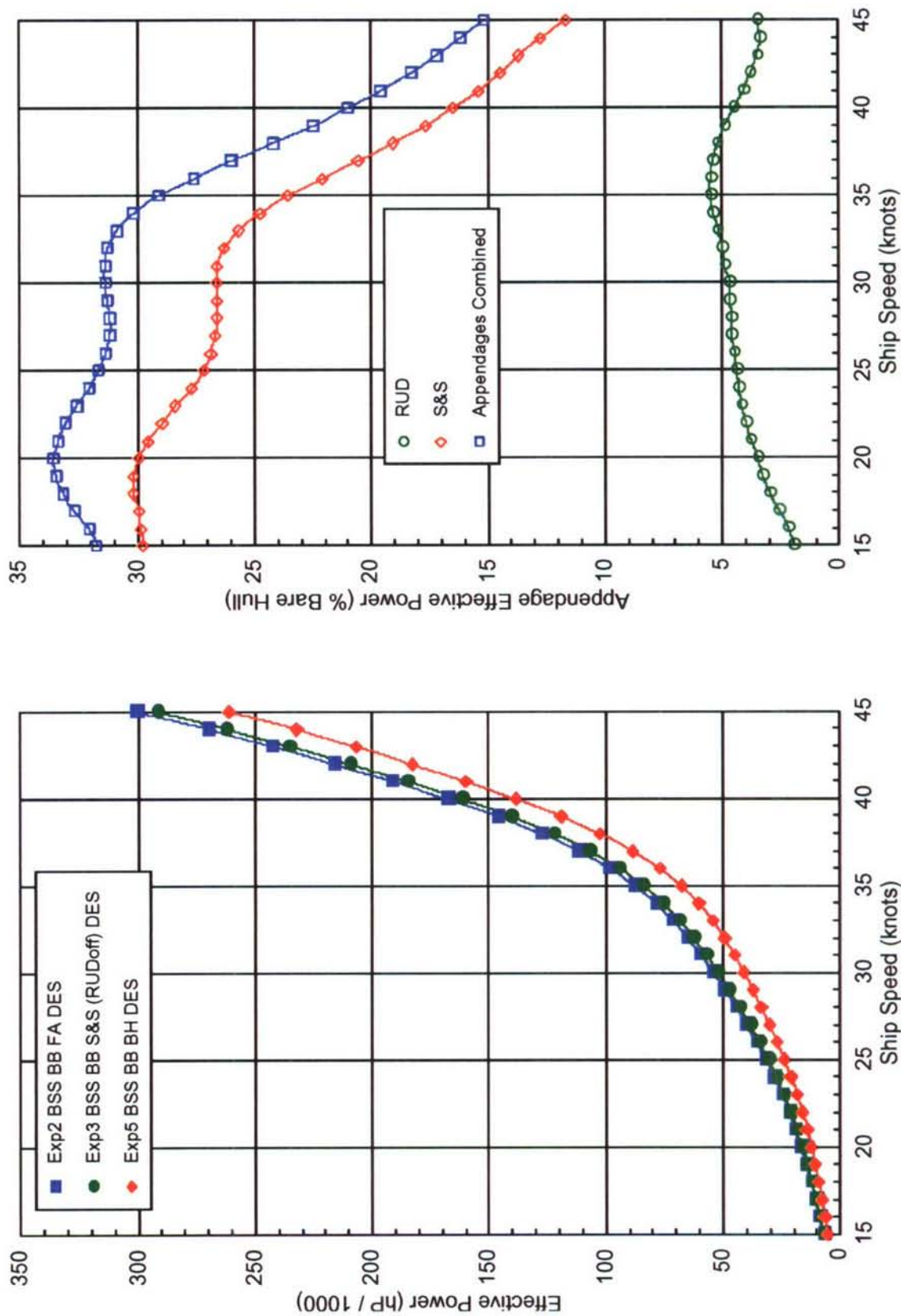


Fig B3. JHSS: BSS, BB, appendage variations, DES, PE test comparisons (continued)

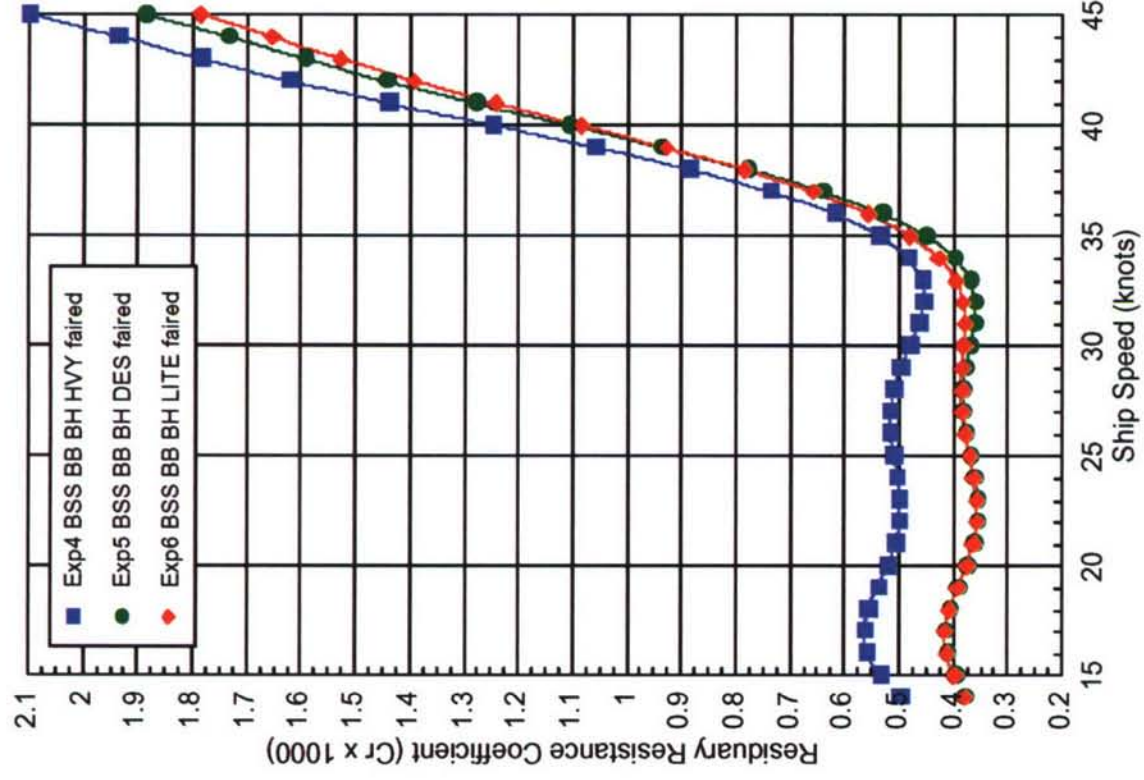
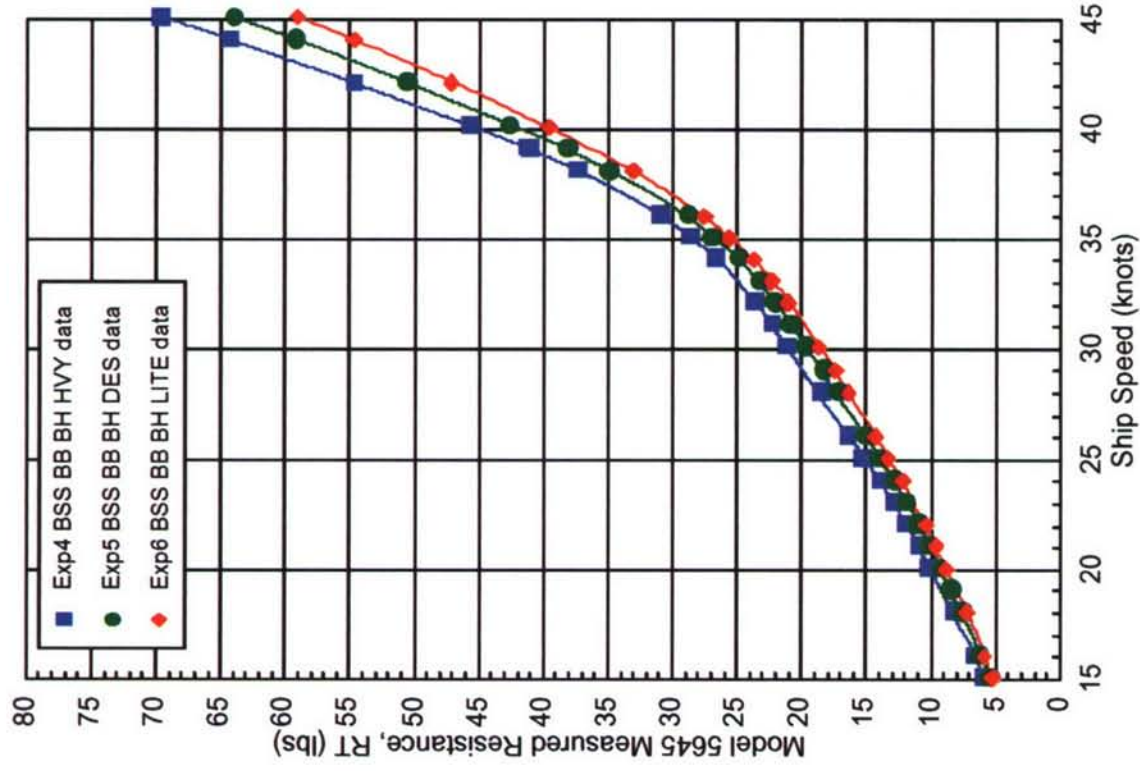


Fig B4. JHSS: BSS, BB, BH, displacement variations, PE test comparisons

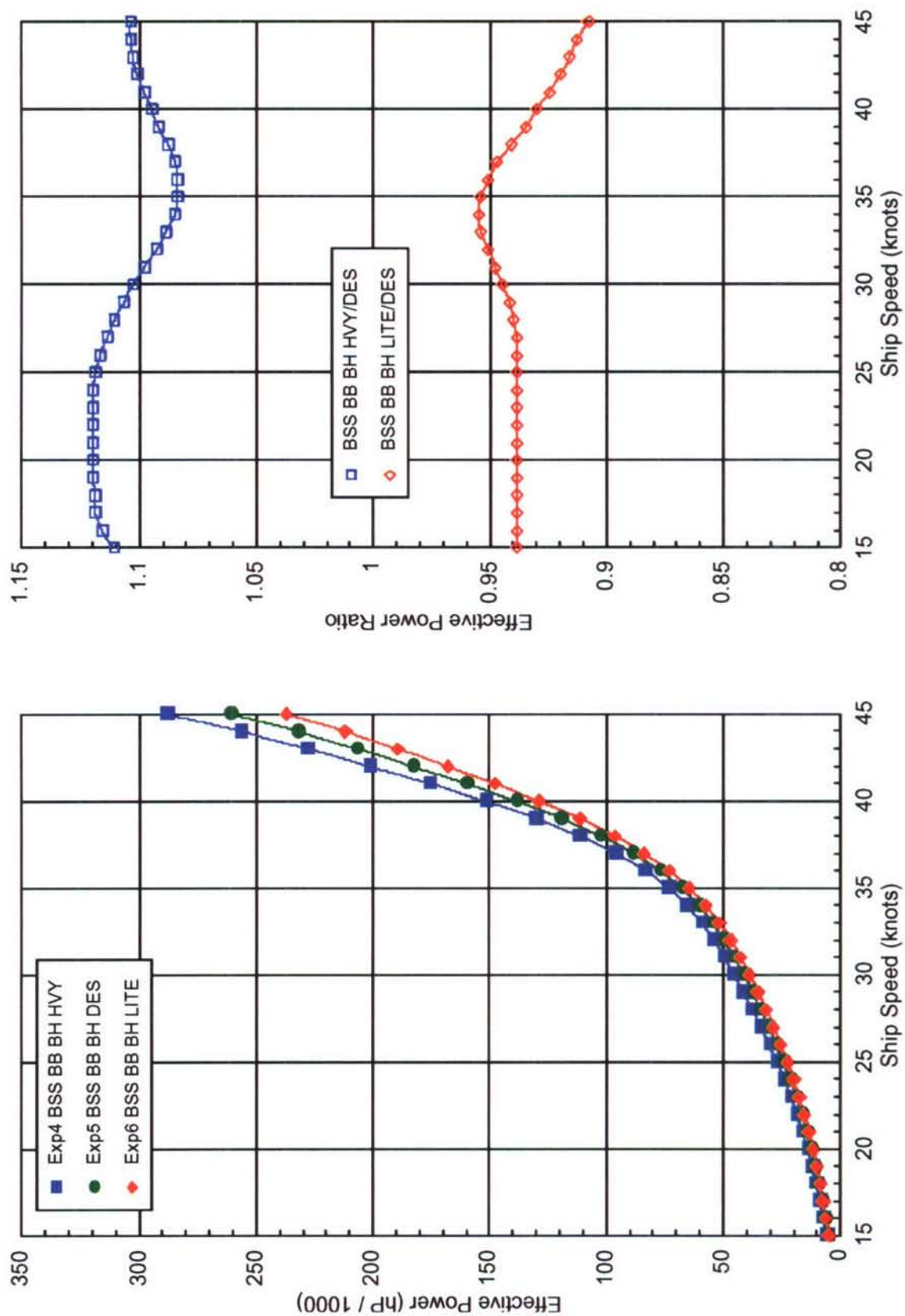


Fig B4. JHSS: BSS, BB, BH, displacement variations, PE test comparisons (continued)

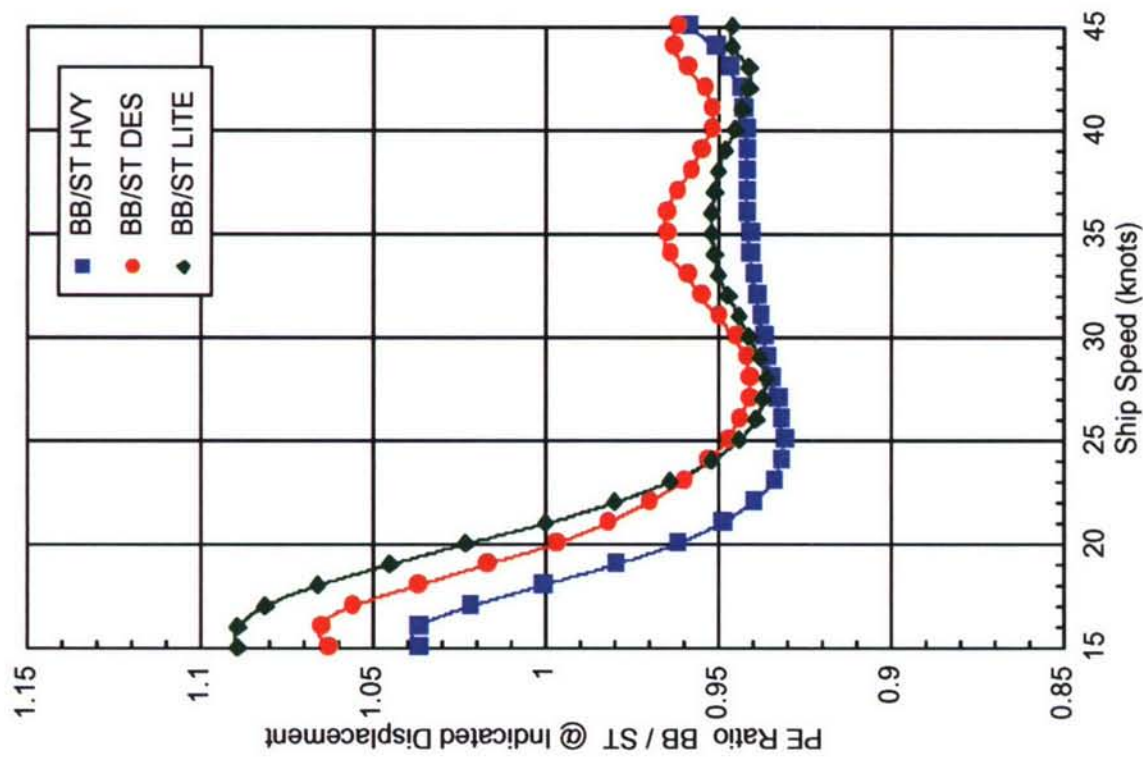
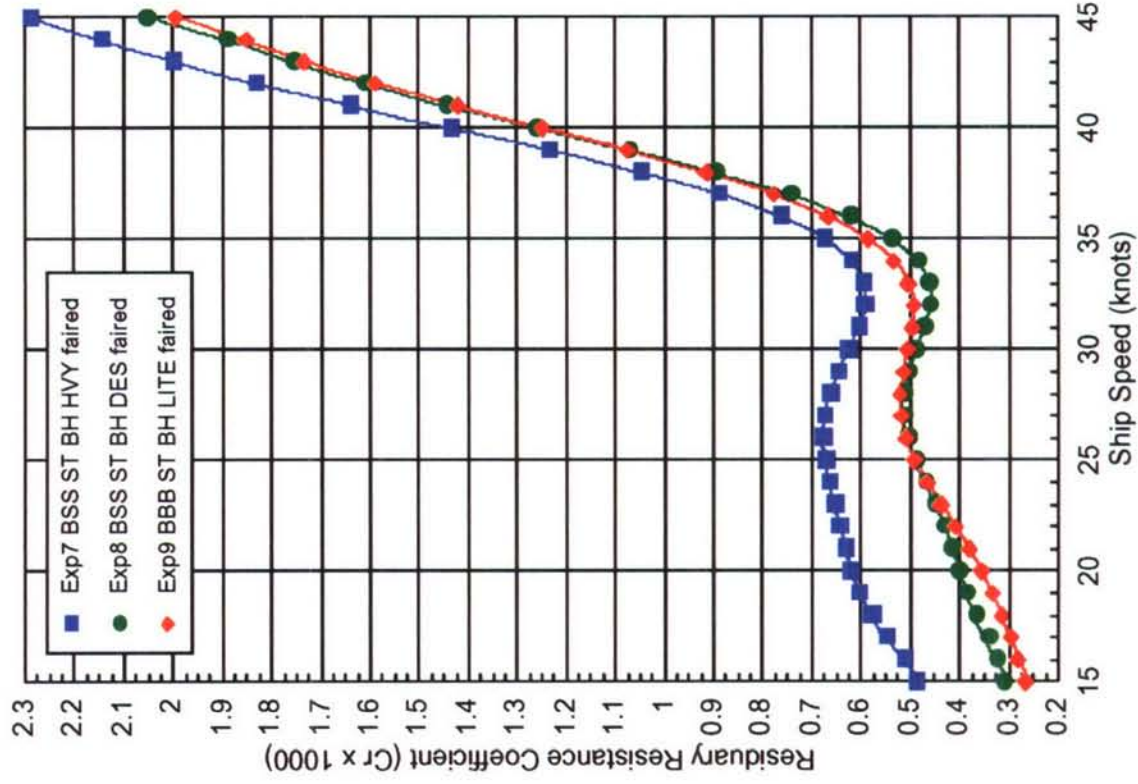
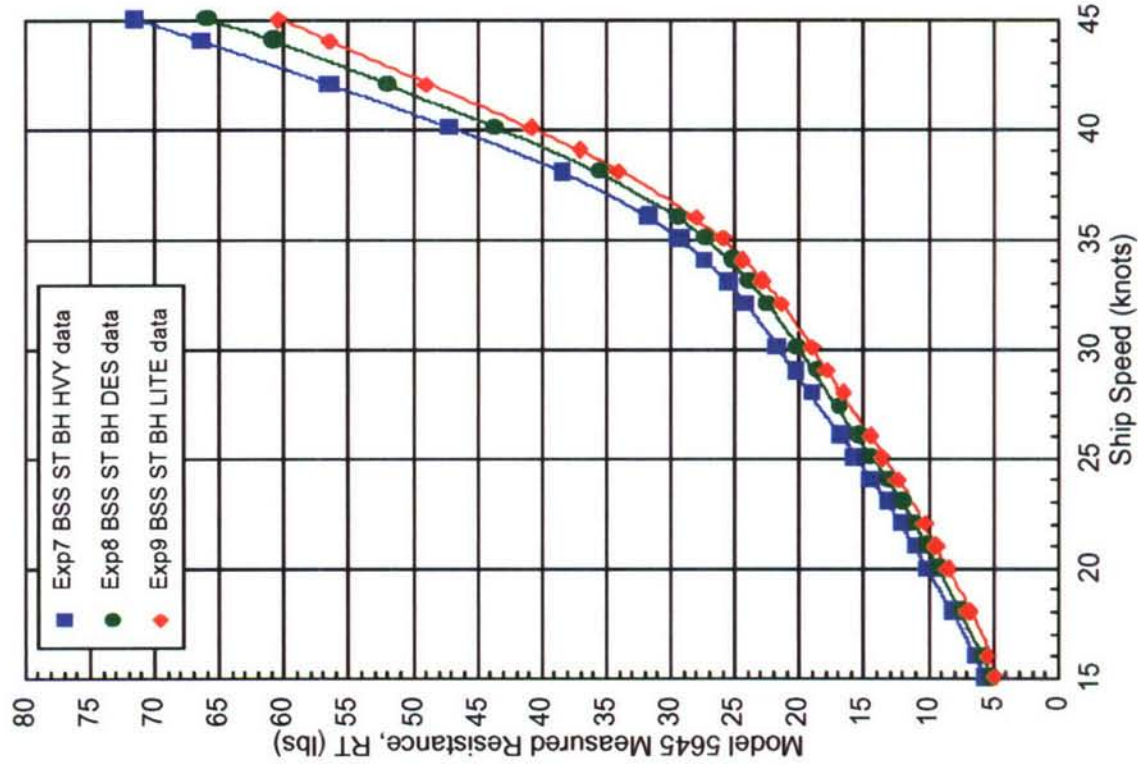
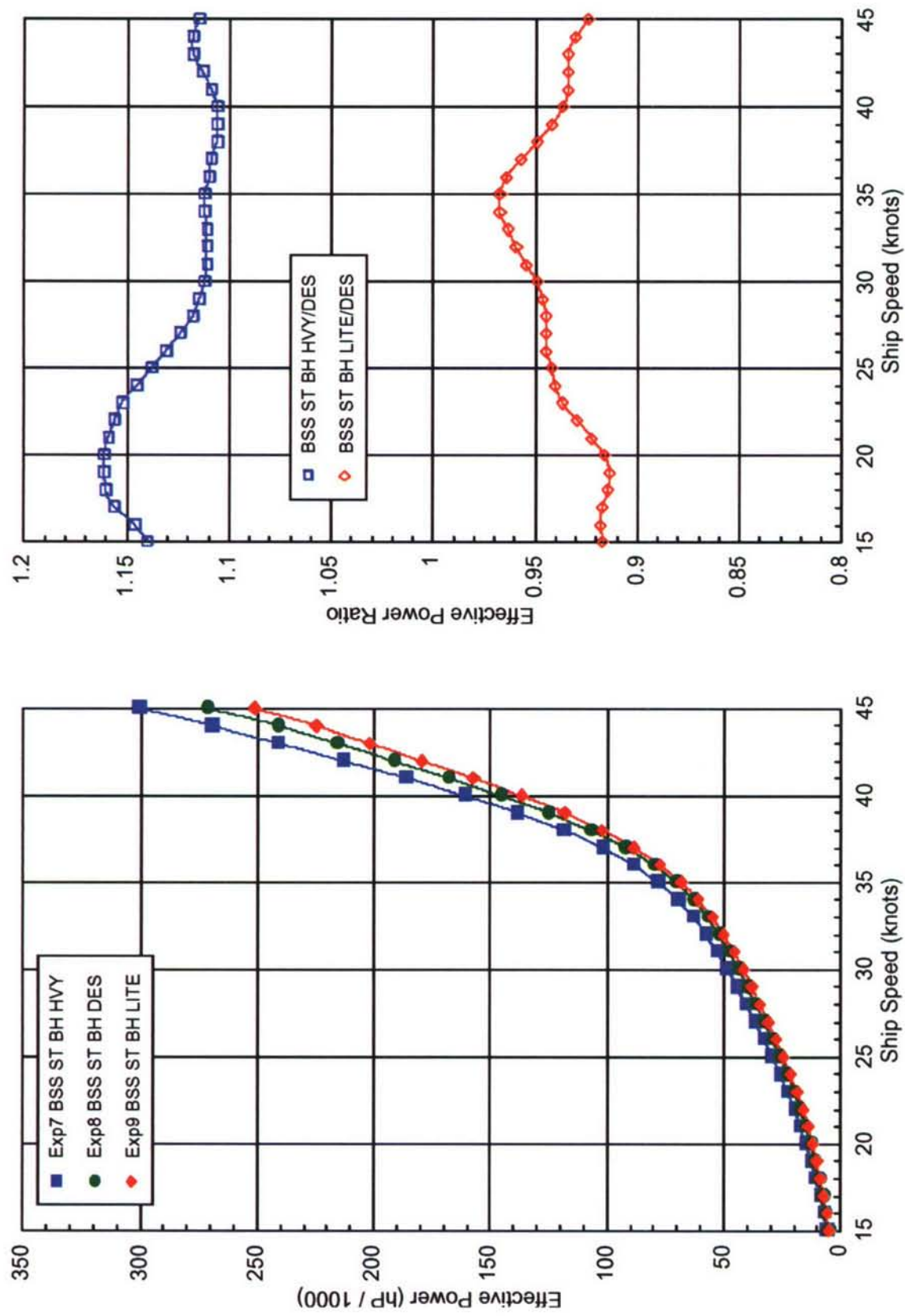


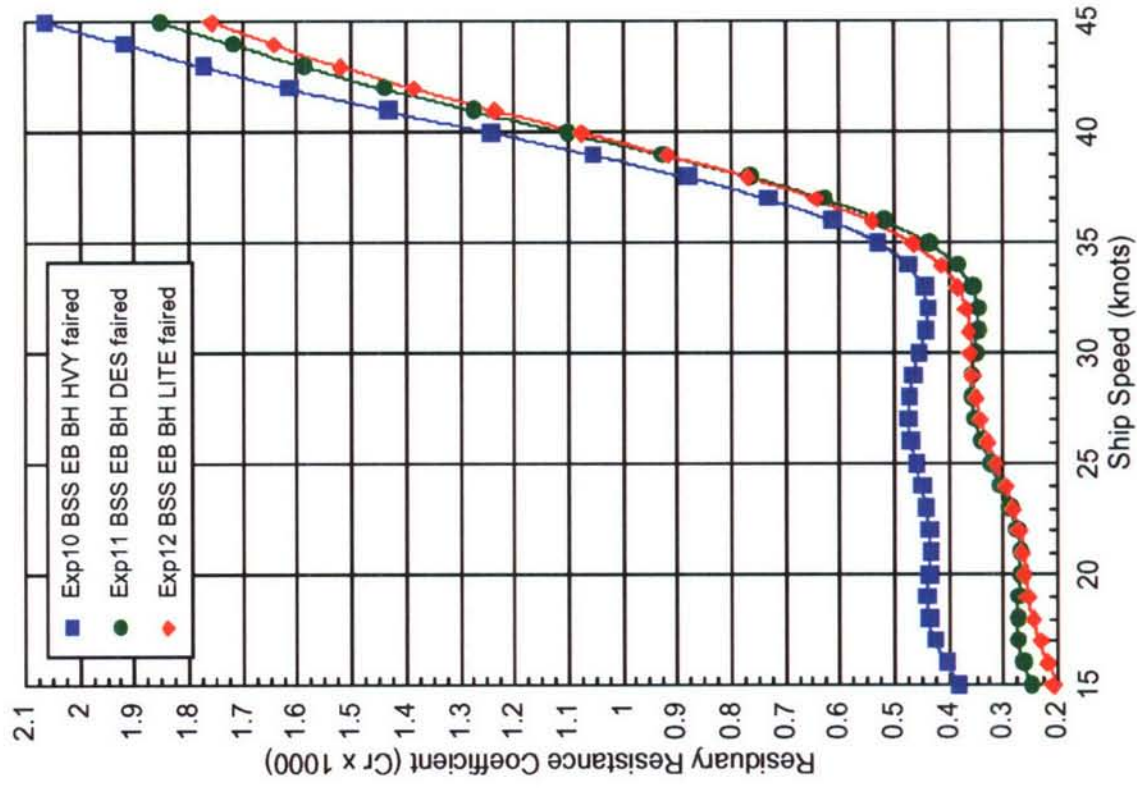
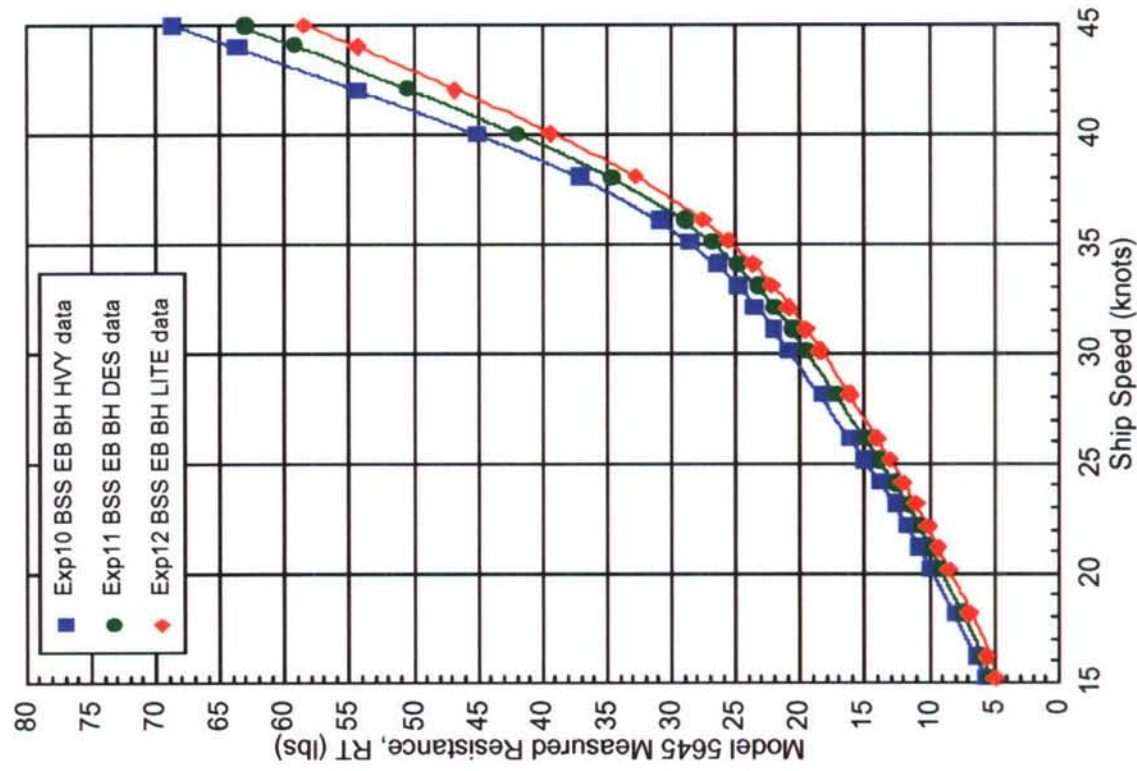
Fig B4. JHSS: BSS, BB, BH, displacement variations, PE test comparisons (continued)



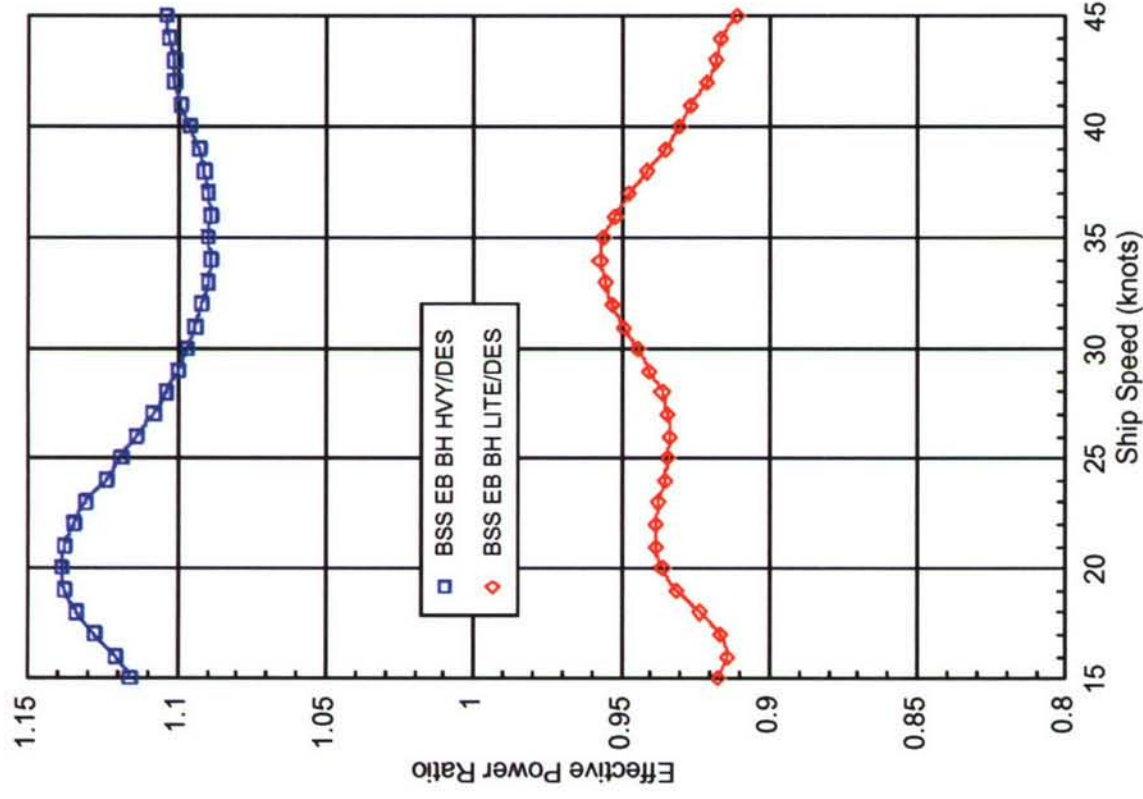
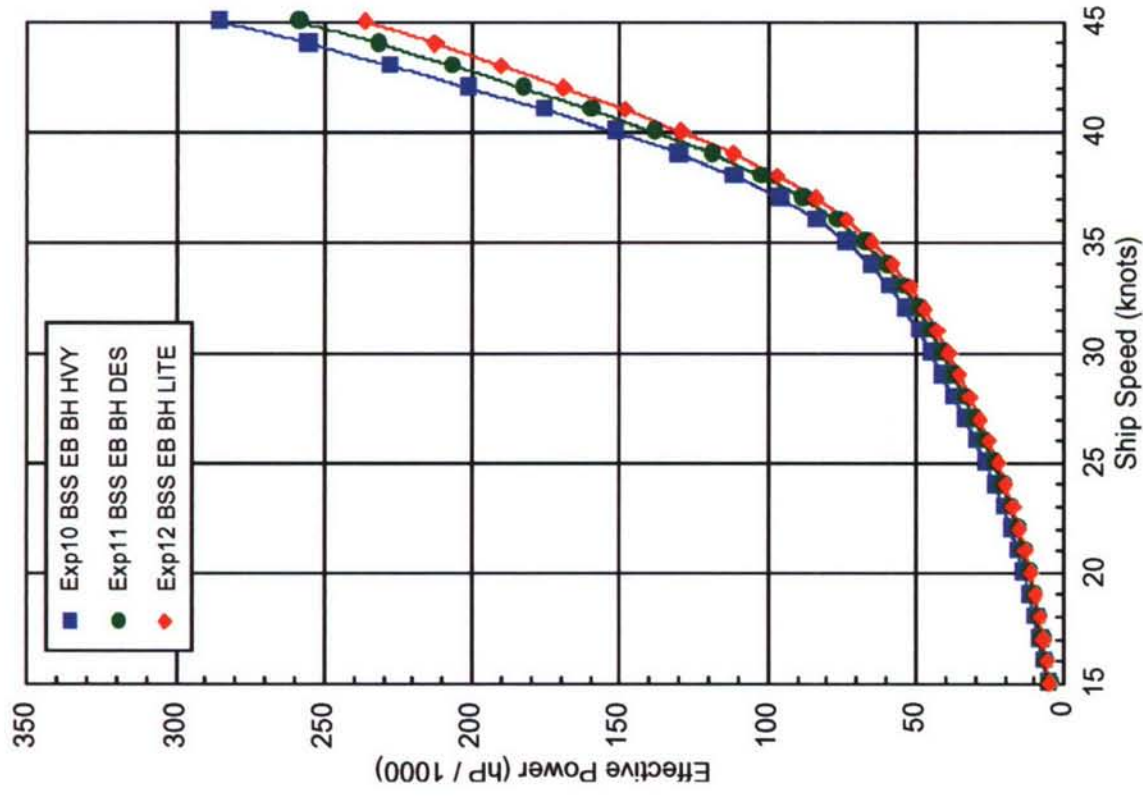
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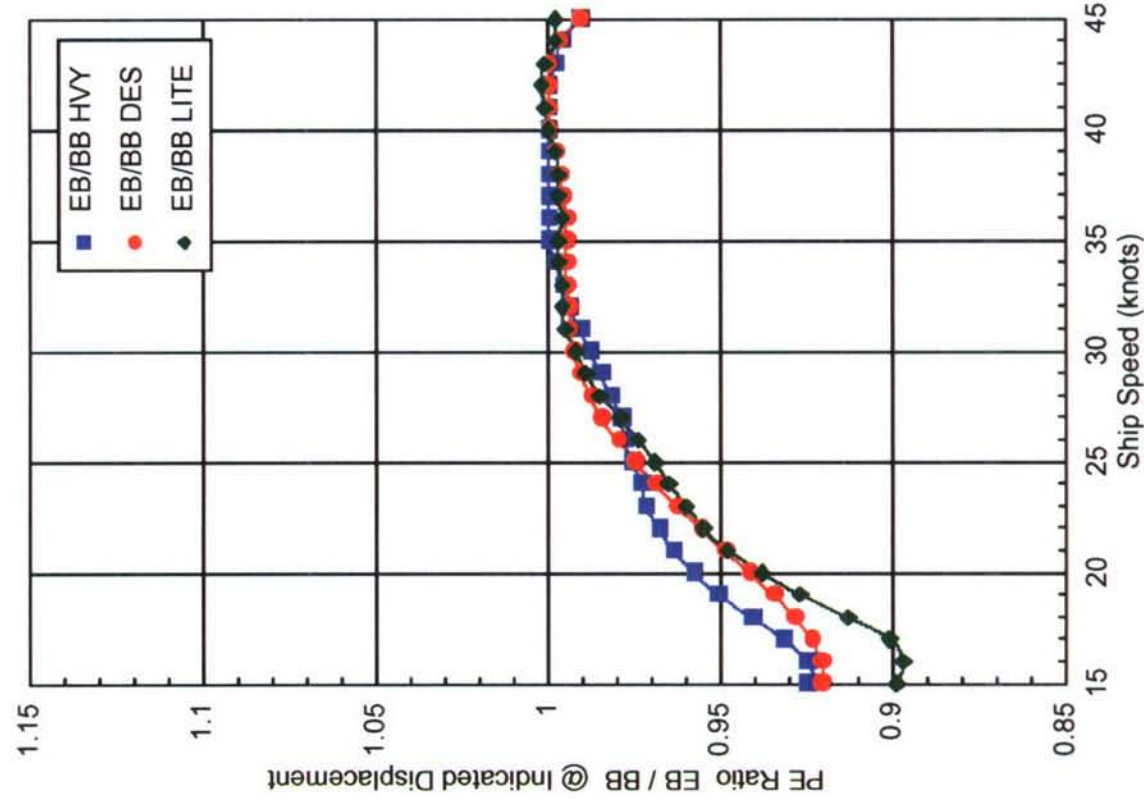
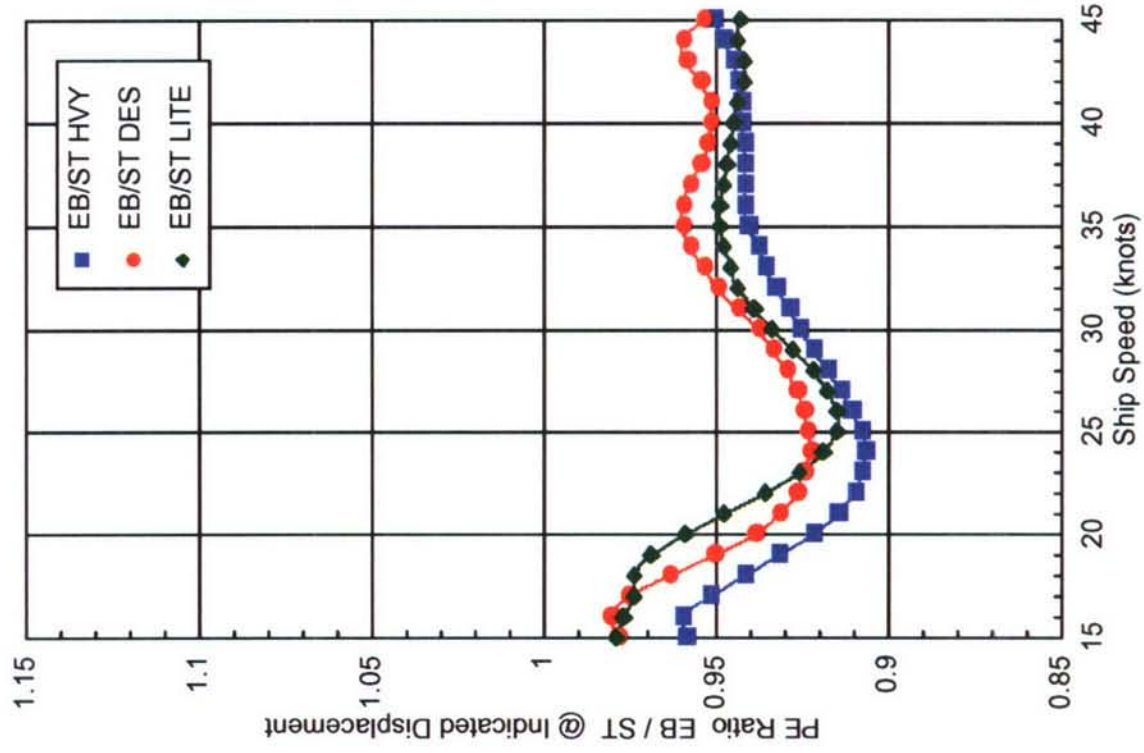
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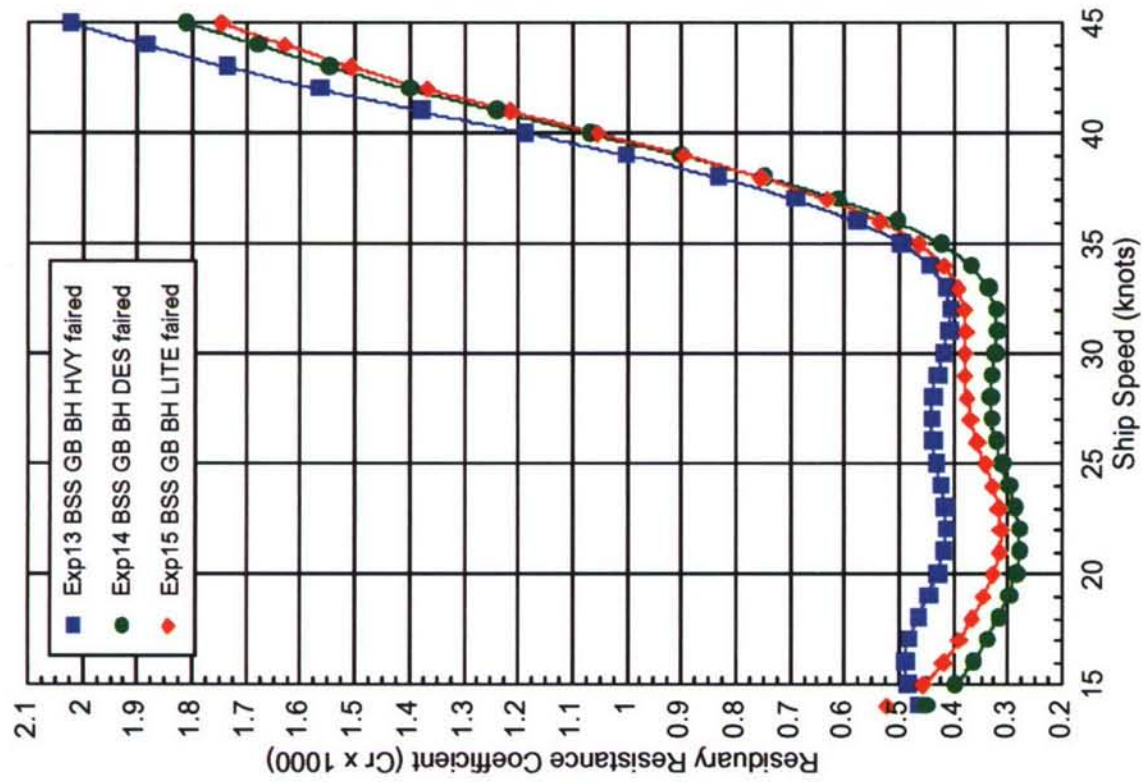
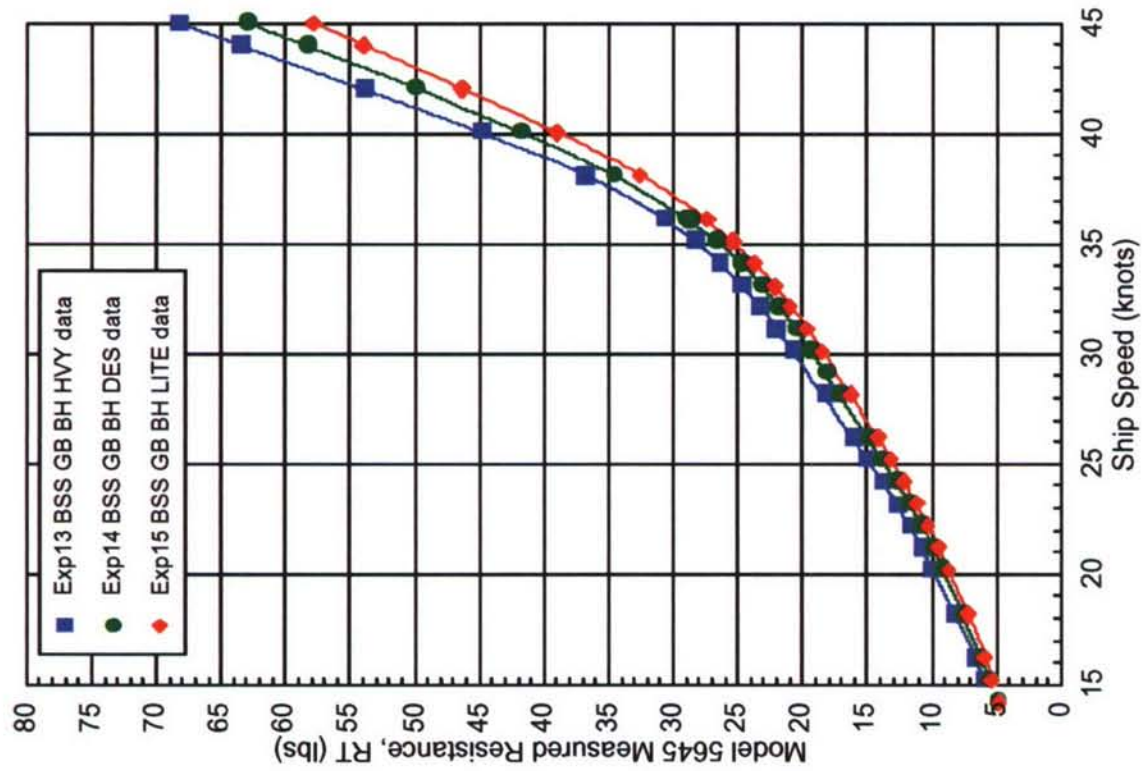
B6. JHSS: BSS, EB, BH, displacement variations, PE test comparisons



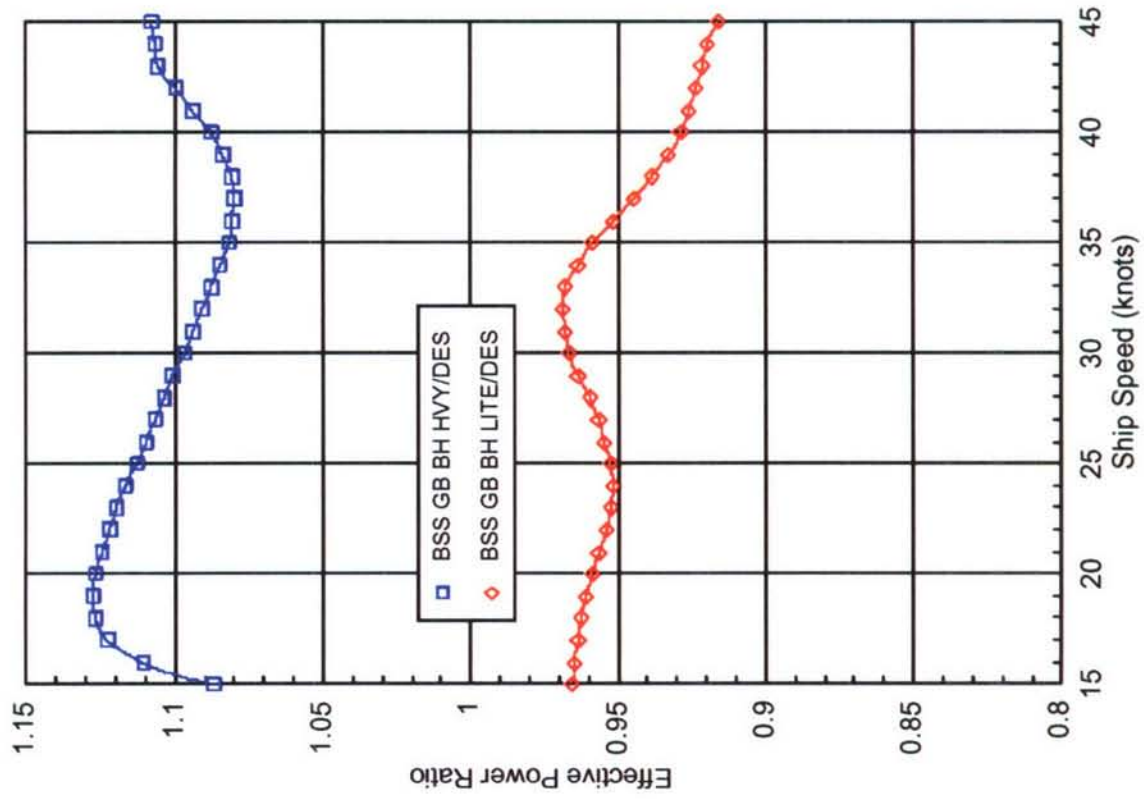
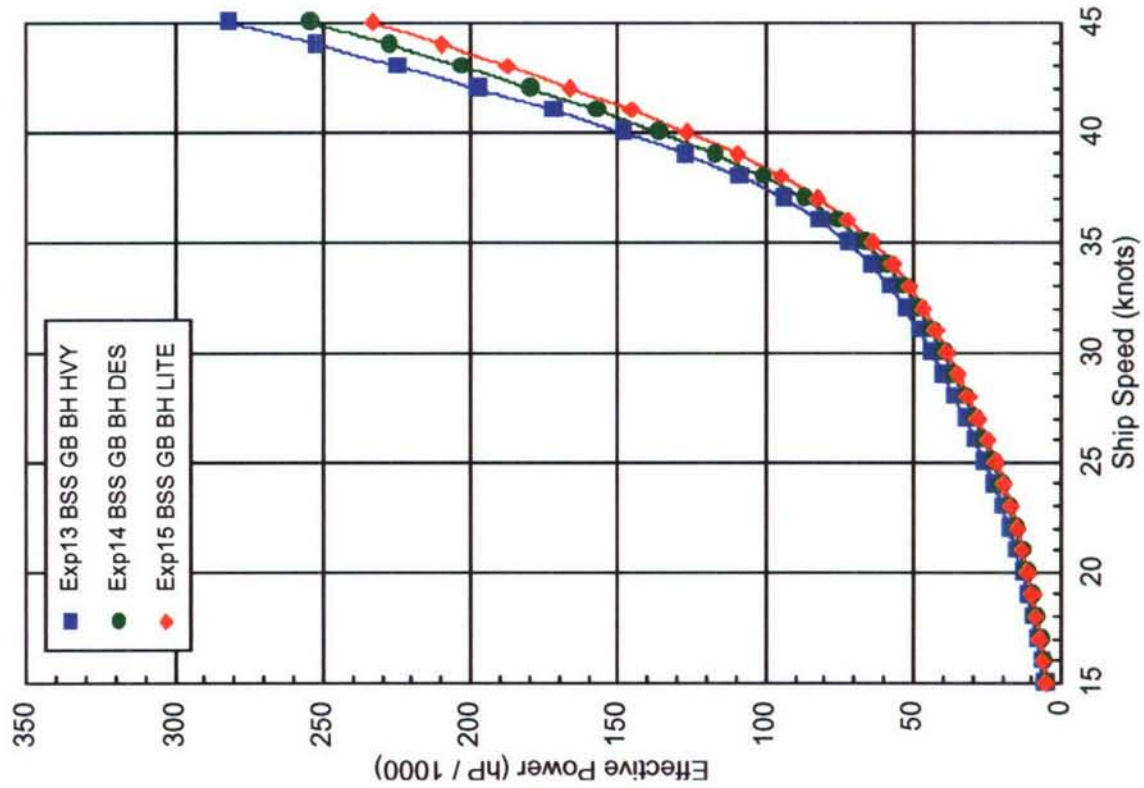
B6. JHSS: BSS, EB, BH, displacement variations, PE test comparisons (continued)



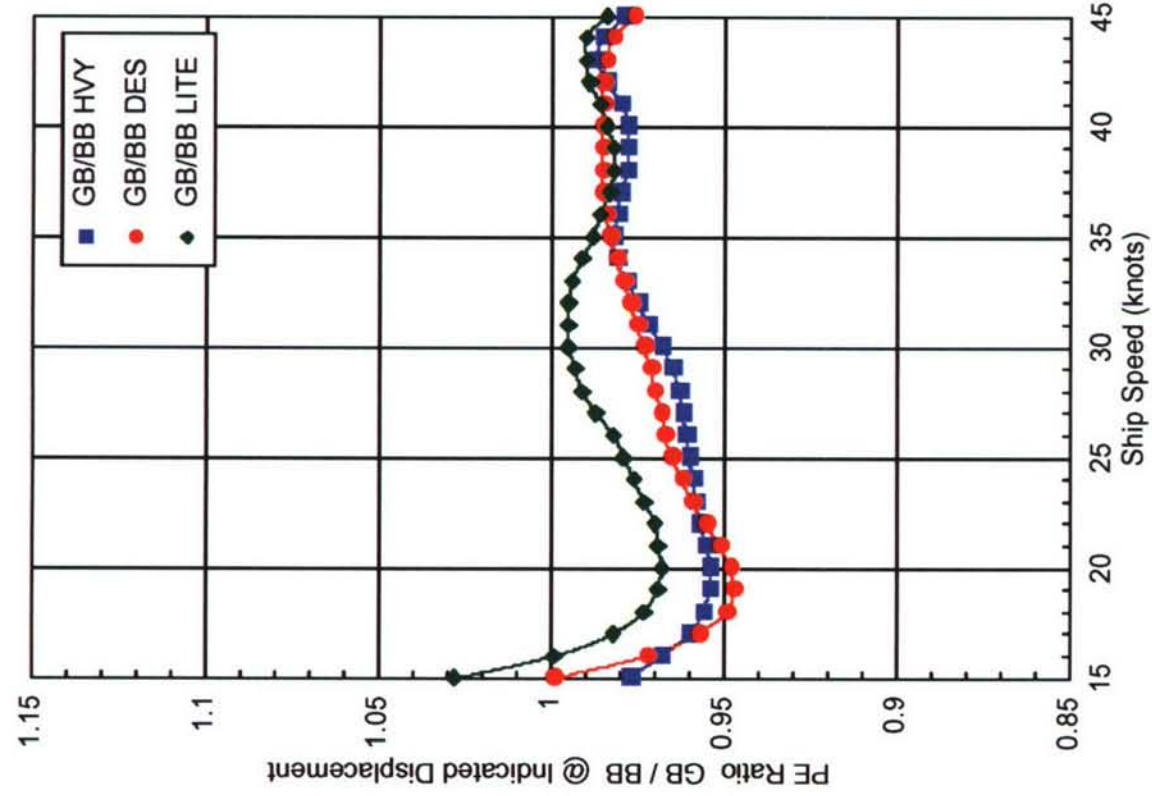
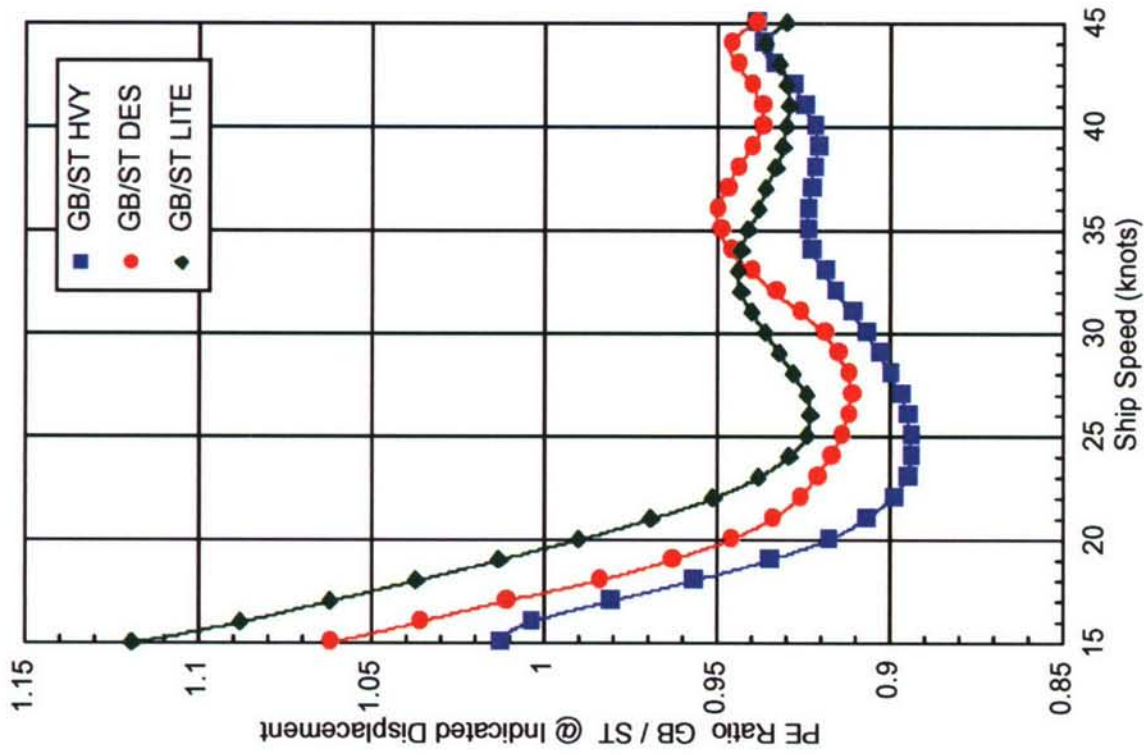
B6. JHSS: BSS, EB, BH, displacement variations, PE test comparisons (continued)



B7. JHSS: BSS, GB, BH, displacement variations, PE test comparisons



B7. JHSS: BSS, GB, BH, displacement variations, PE test comparisons (continued)



B7. JHSS: BSS, GB, BH, displacement variations, PE test comparisons (continued)

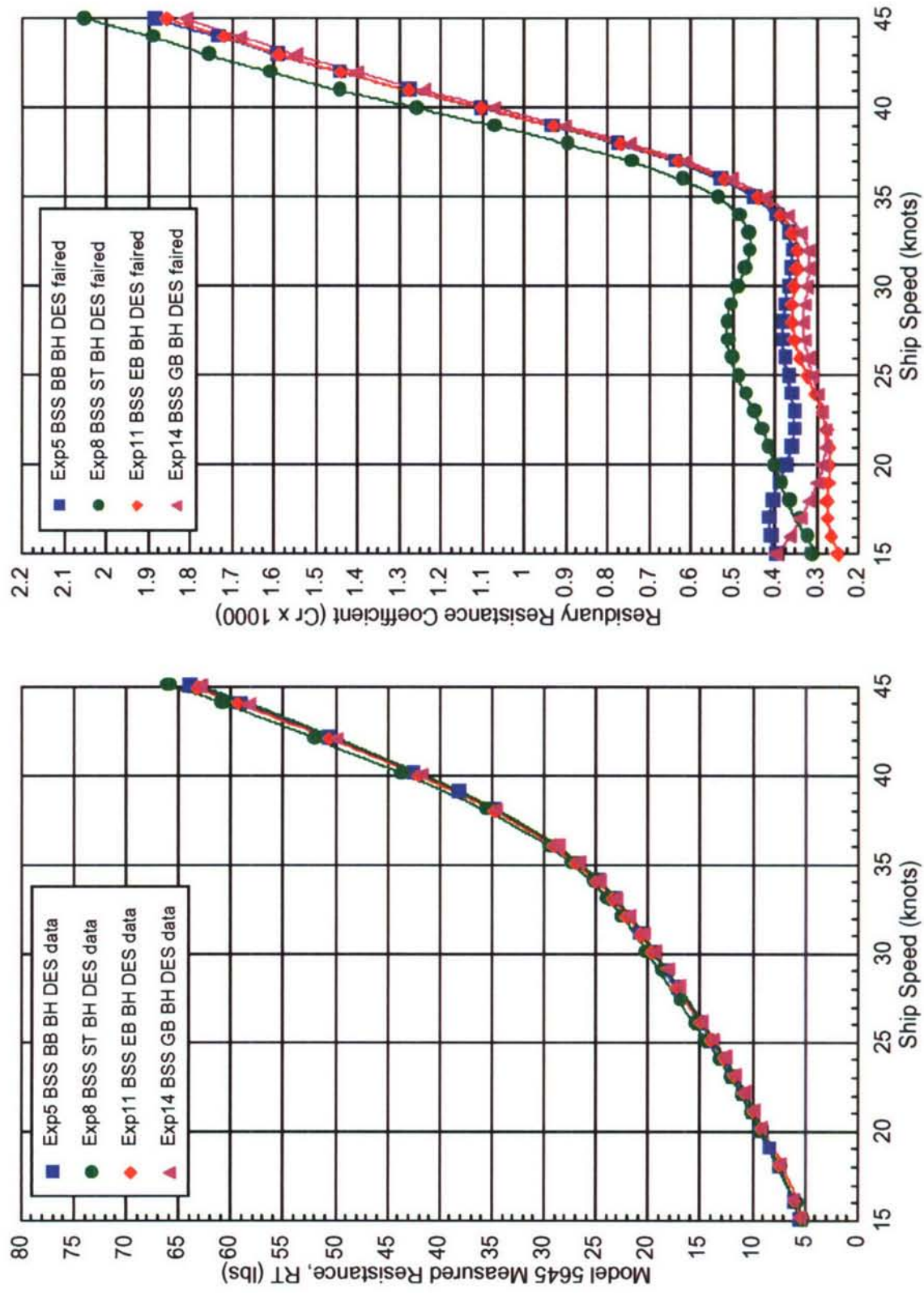


Fig B8. JHSS: BSS, bow variations, BH, DES, PE test comparisons

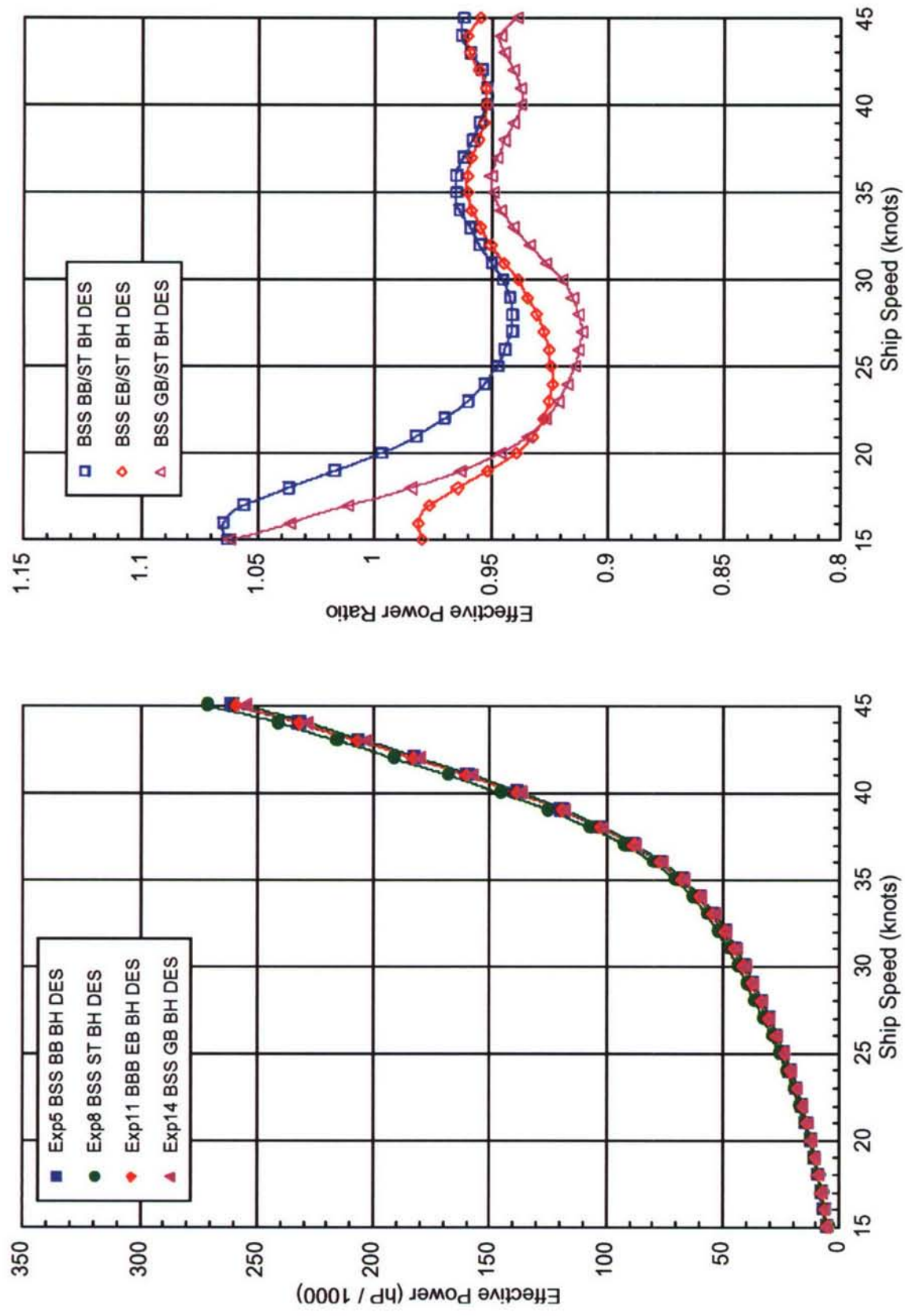


Fig B8. JHSS: BSS, bow variations, BH, DES, PE test comparisons (continued)

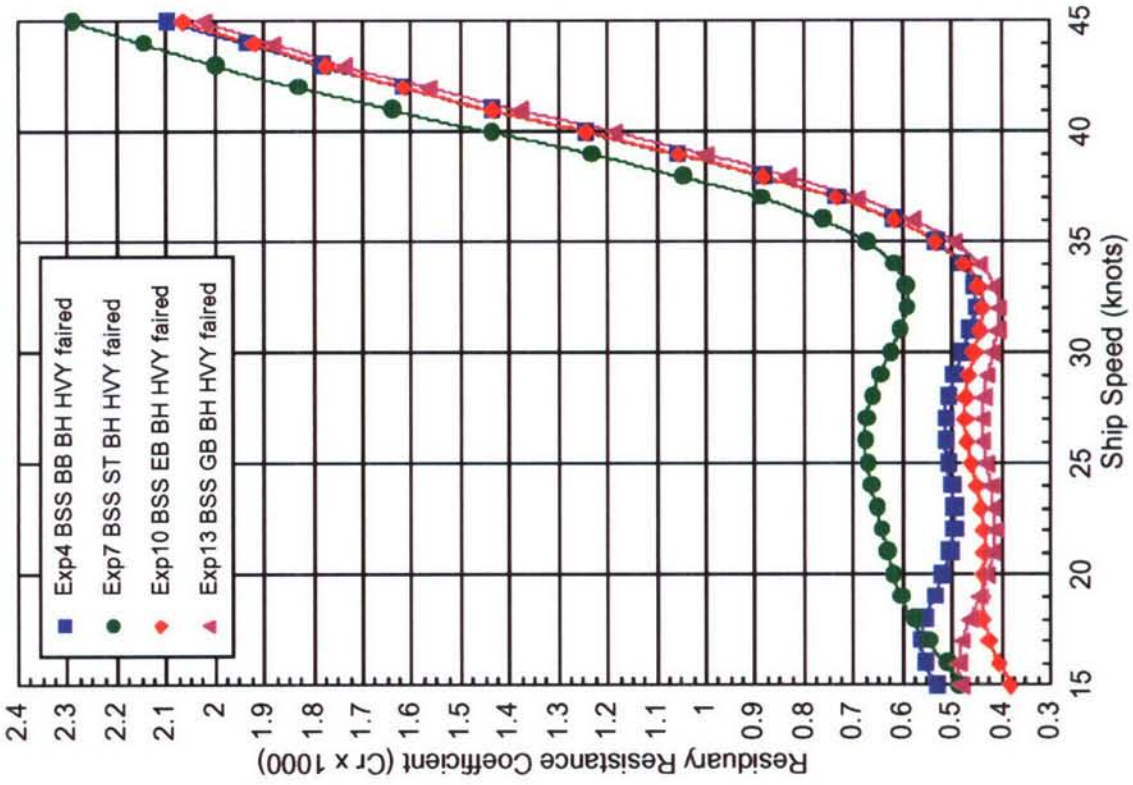
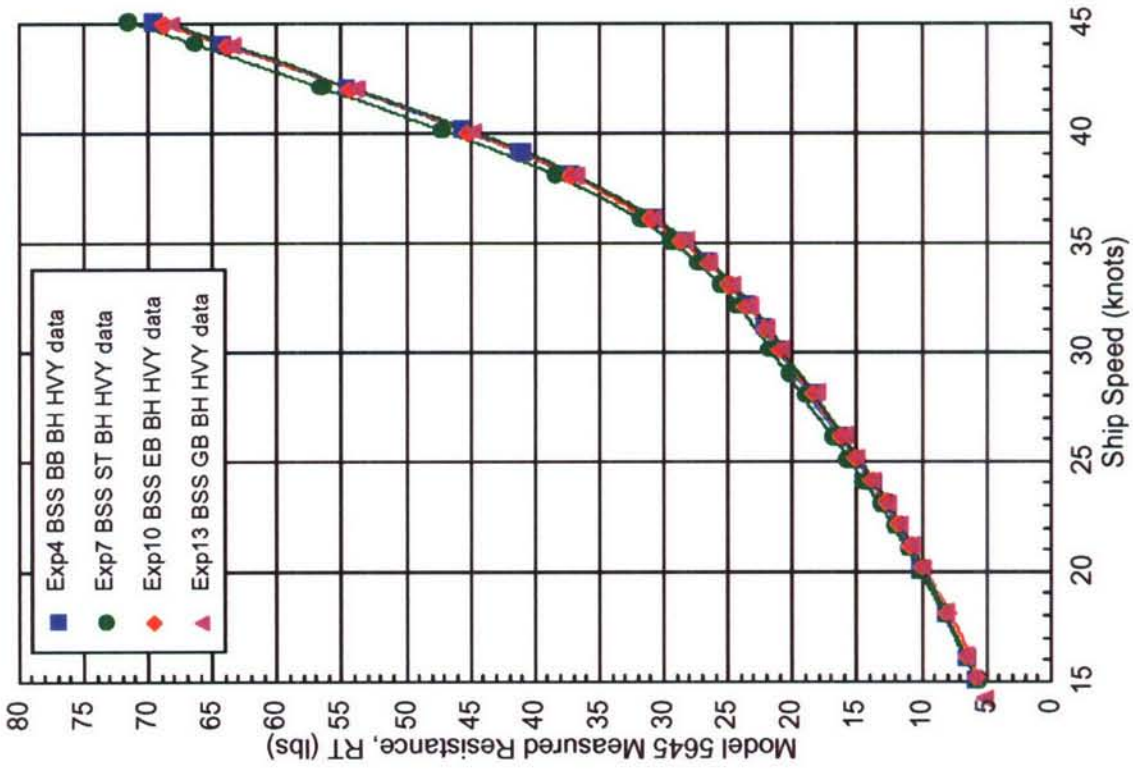


Fig B9. JHSS: BSS, bow variations, BH, HVY, PE test comparisons

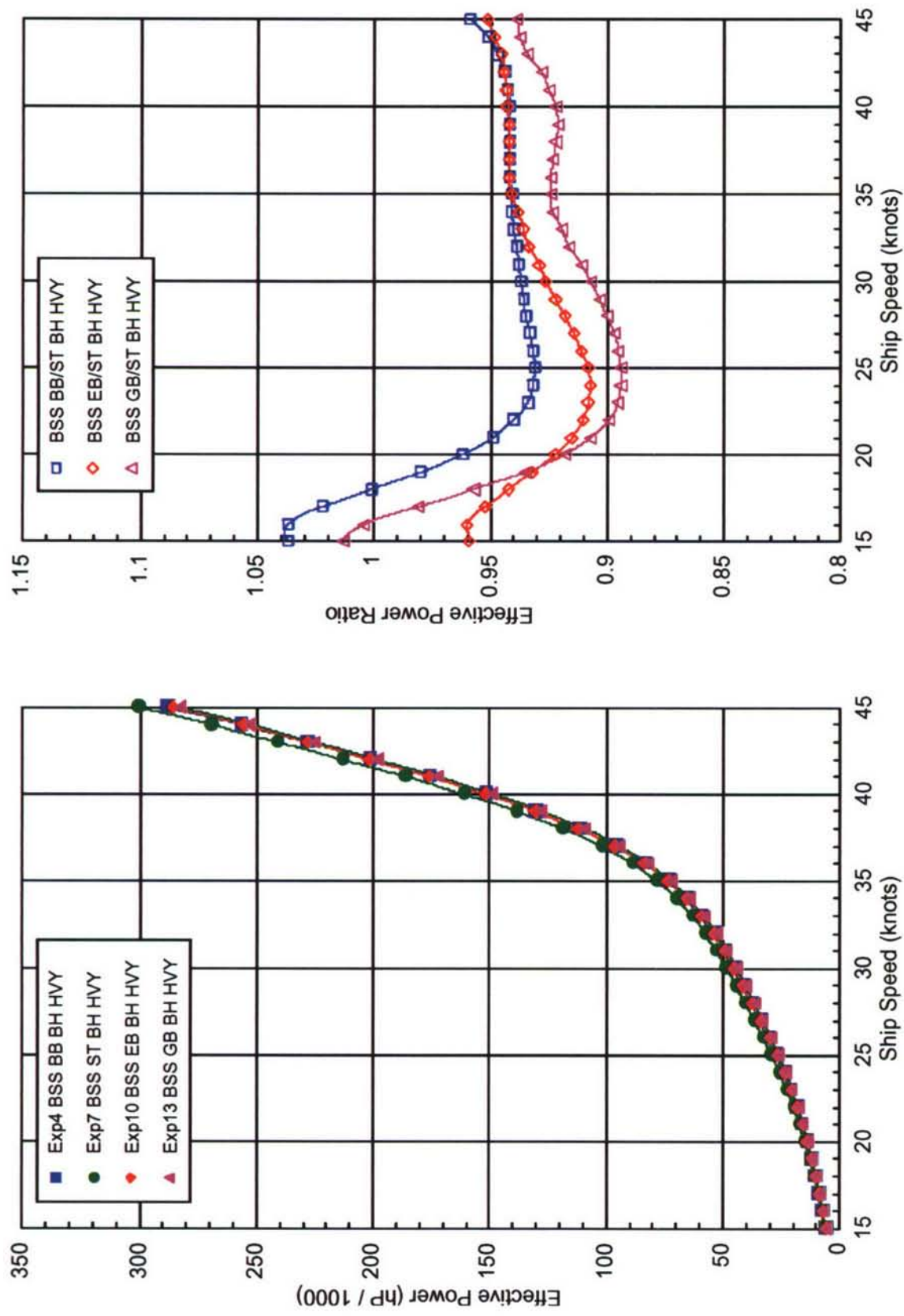


Fig B9. JHSS: BSS, bow variations, BH, HVY, PE test comparisons (continued)

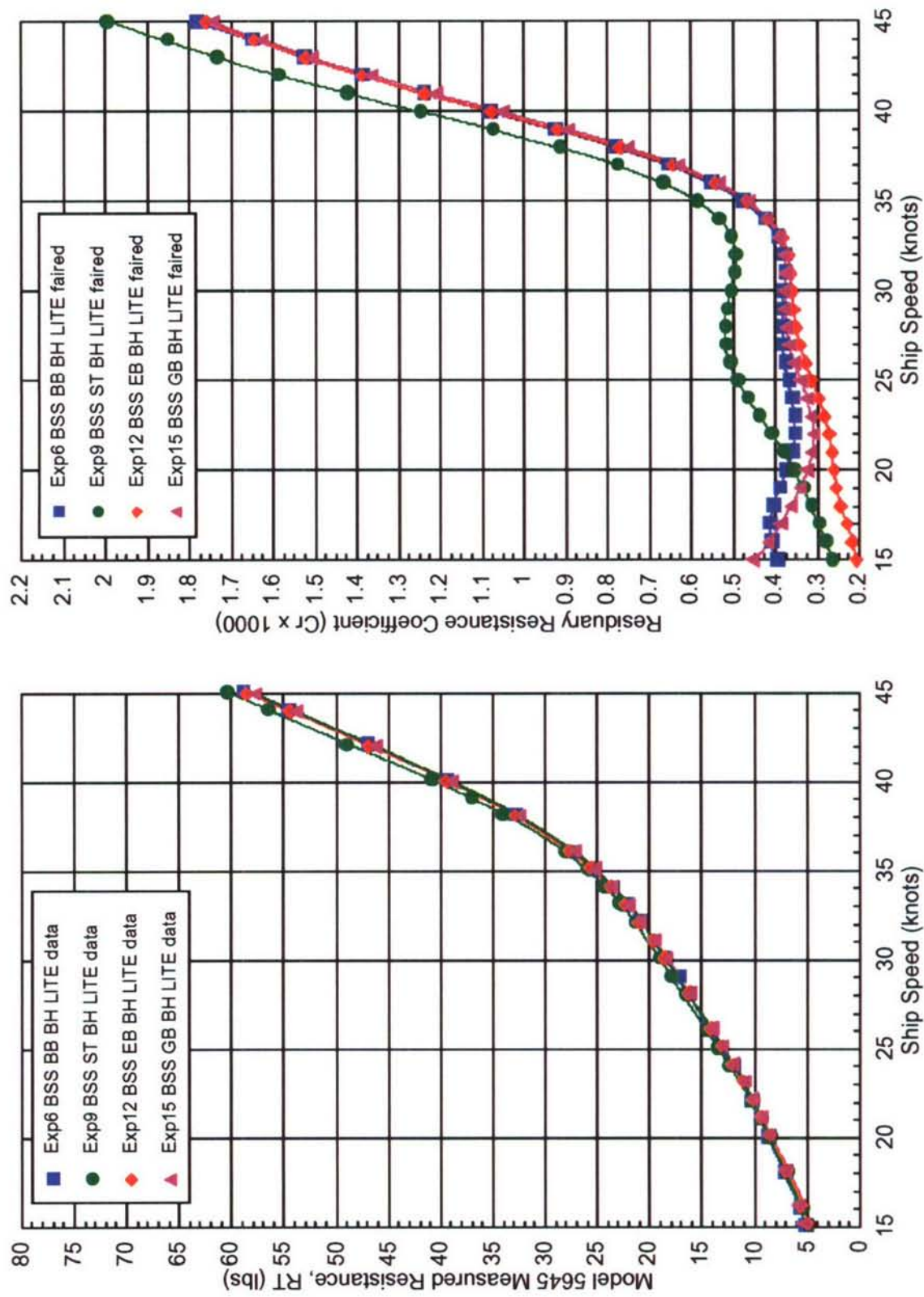


Fig B10. JHSS: BSS, bow variations, BH, LITE, PE test comparisons

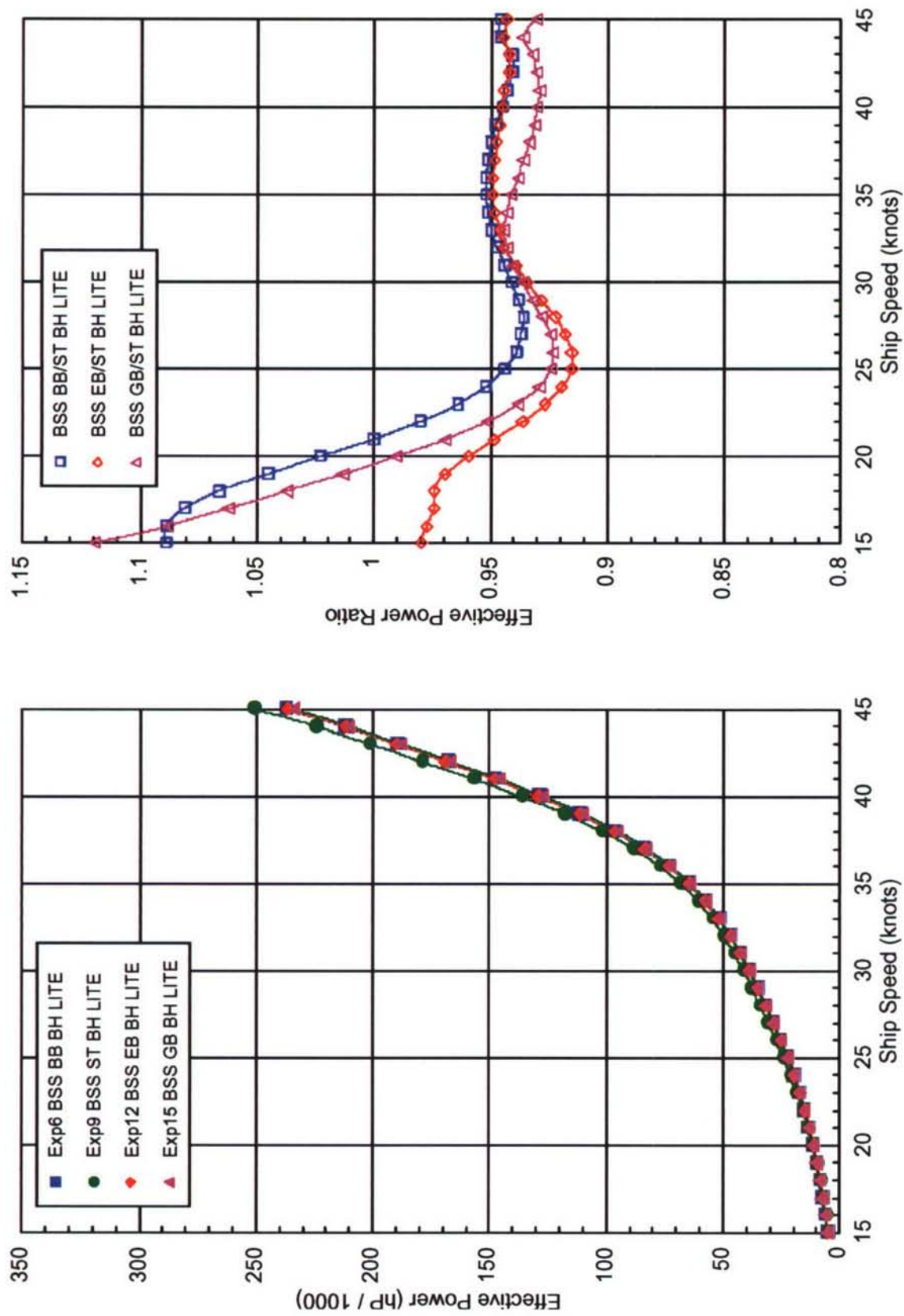
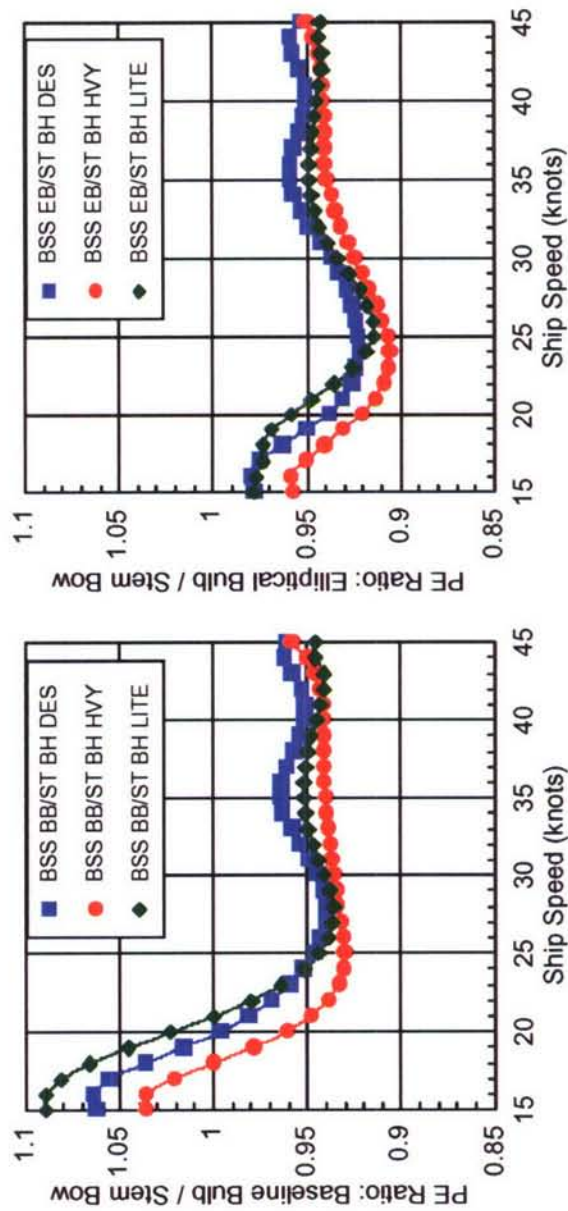


Fig B10. JHSS: BSS, bow variations, BH, LITE, PE test comparisons (continued)



JHSS Baseline Shaft & Strut (BSS), bare hull (BH) resistance comparisons of Baseline Bulb (BB), Elliptical Bulb (EB) and Gooseneck Bulb (GB) versus Stern Bow (ST), at Design (DES), Light (LITE), and Heavy (HVY) tested loading conditions

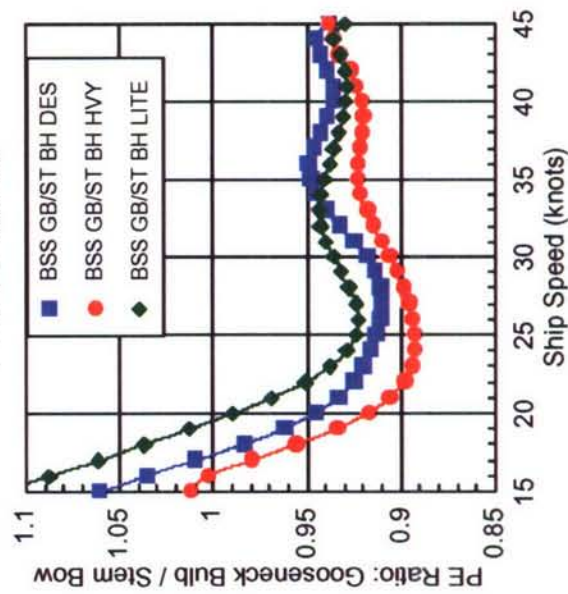
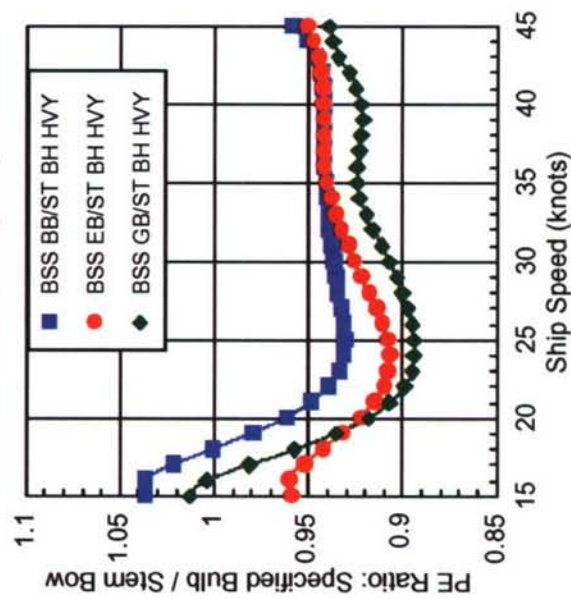
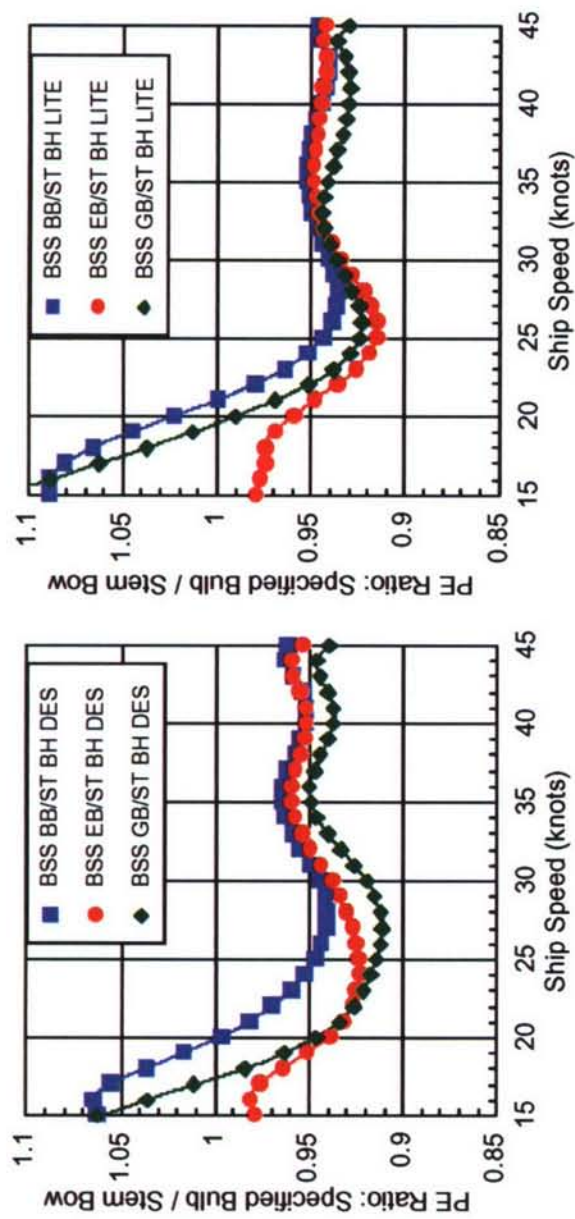


Fig B11. JHSS: BSS, bow bulb resistance summary



JHSS Baseline Shaft & Strut (BSS), bare hull (BH) resistance comparisons of Baseline Bulb (BB), Elliptical Bulb (EB) and Gooseneck Bulb (GB) versus Stem Bow (ST), at Design (DES), Light (LITE), and Heavy (HVY) tested loading conditions

Fig B11. JHSS: BSS, bow bulb resistance summary (continued)

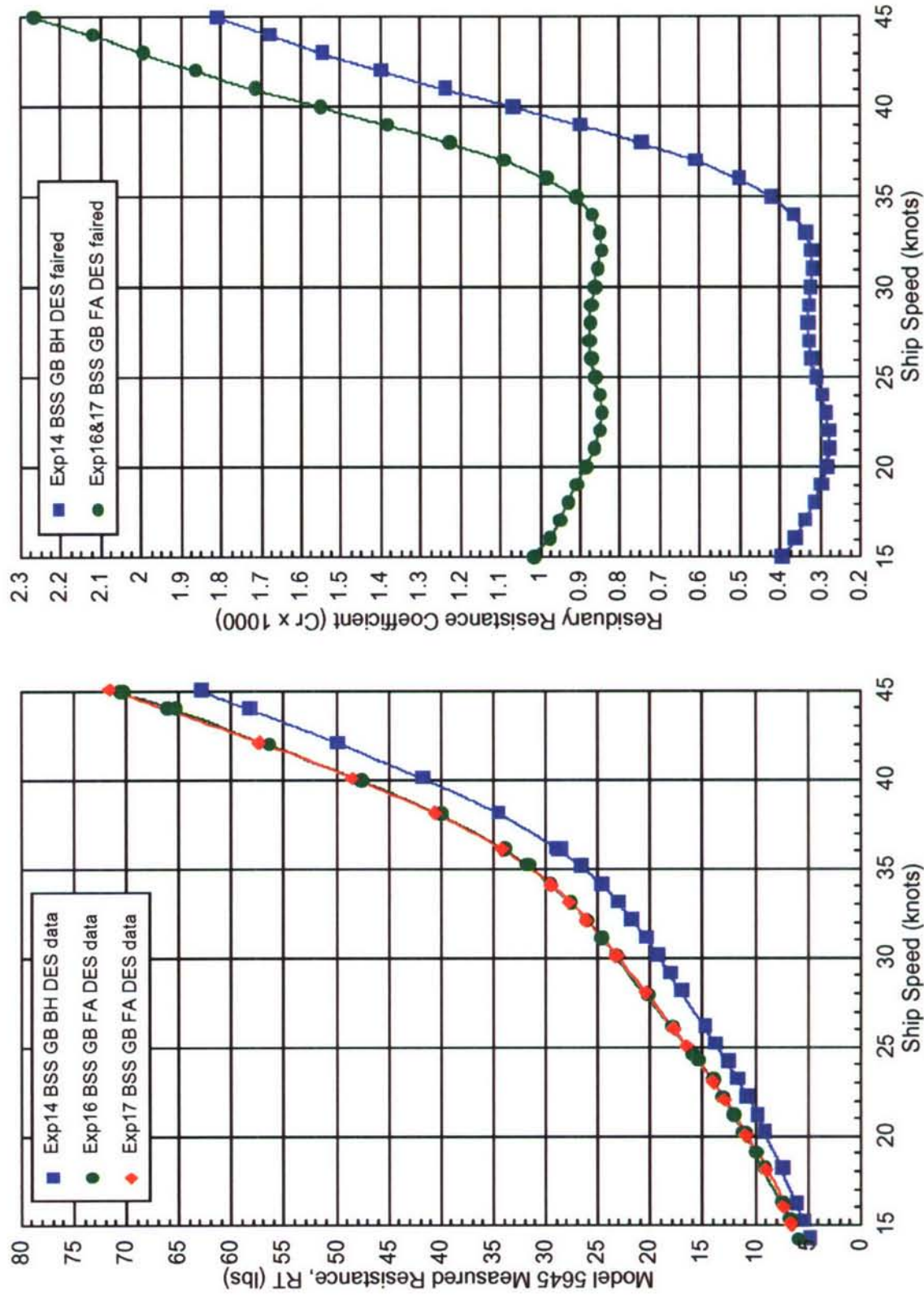


Fig B12. JHSS: BSS, GB, appendage variations, DES, PE test comparisons

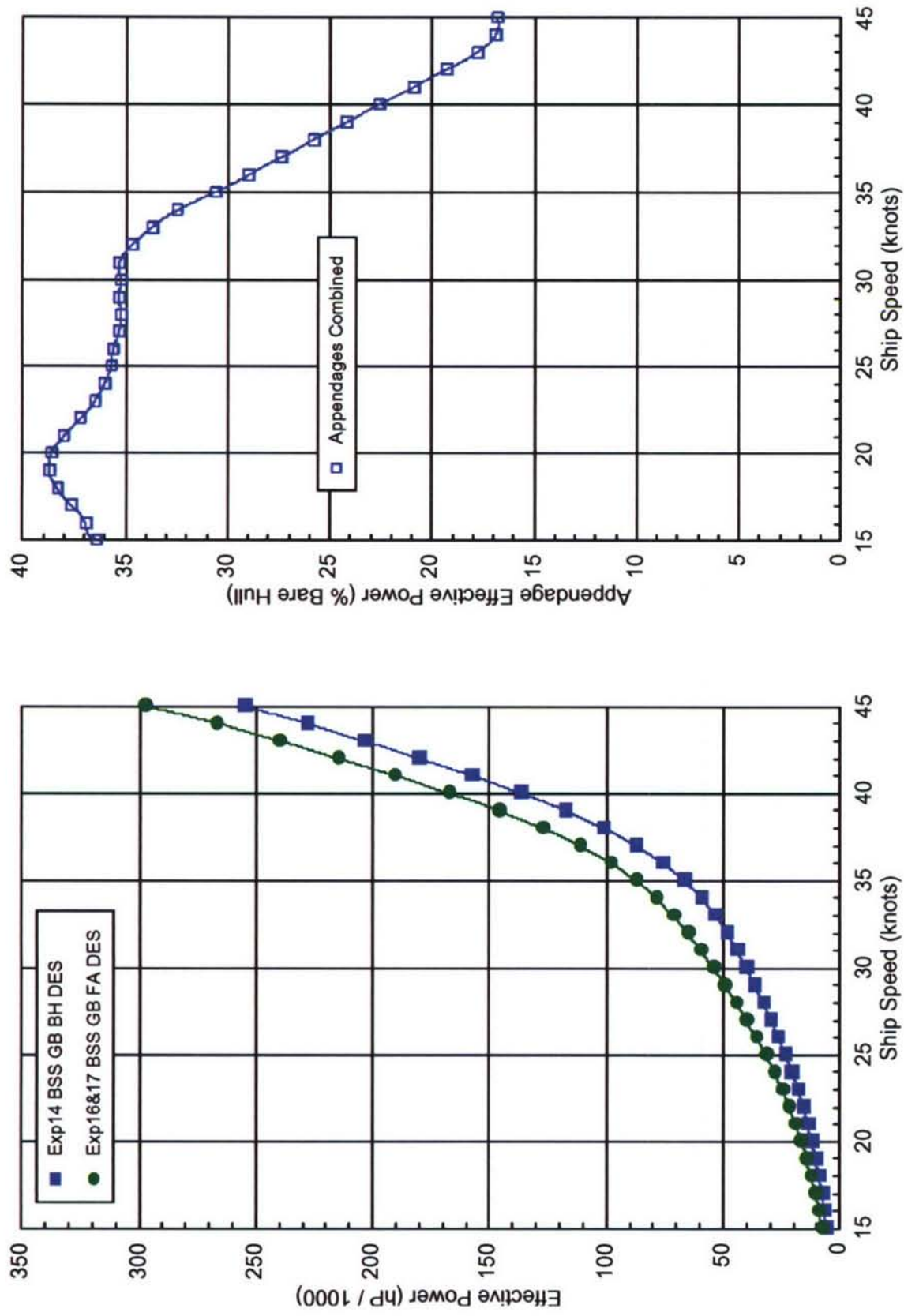


Fig B12. JHSS: BSS, GB, appendage variations, DES, PE test comparisons (continued)

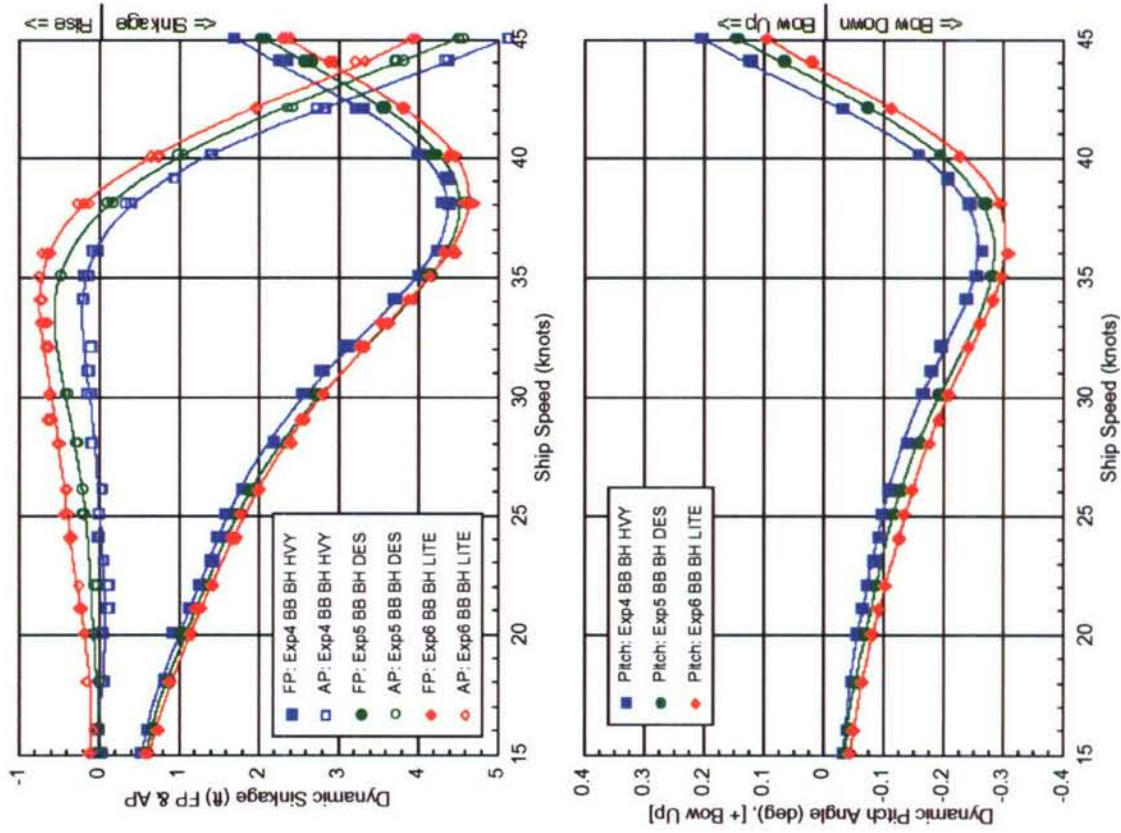


Fig B13. JHSS: BSS, BB, dynamic sinkage and pitch

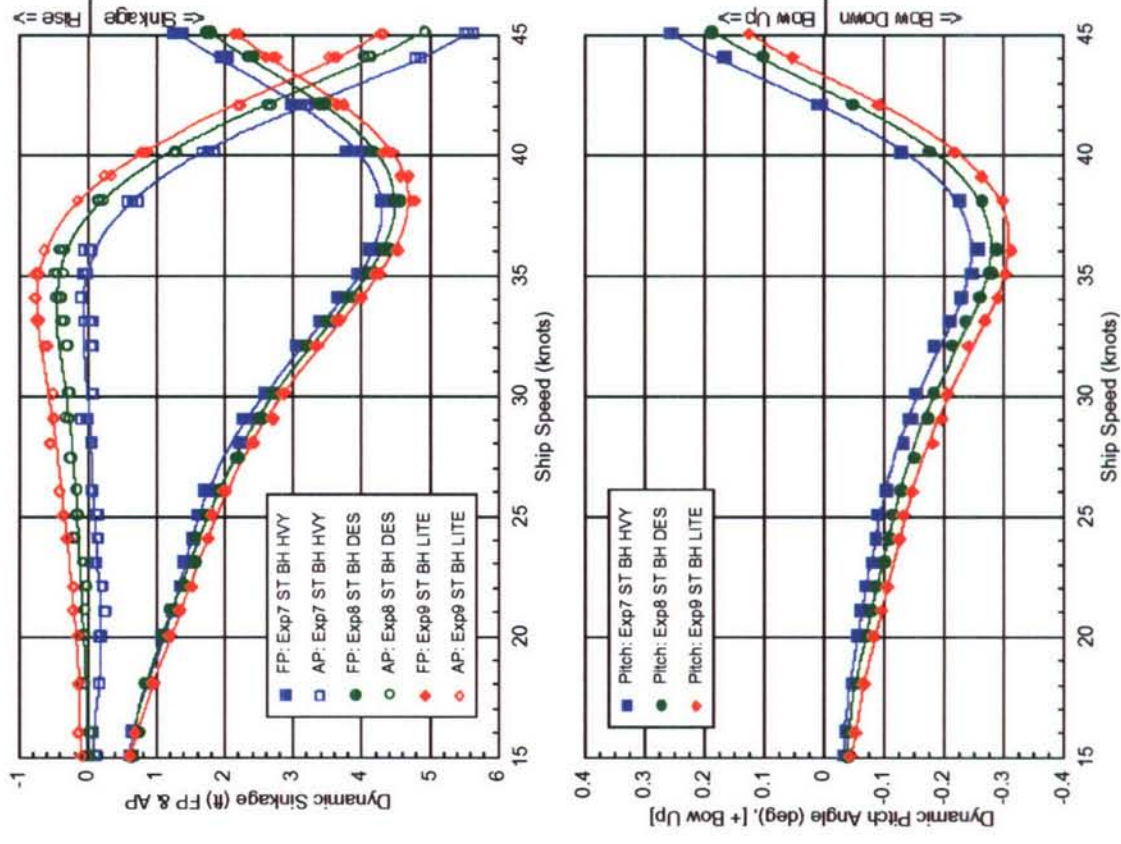


Fig B14. JHSS: BSS, ST, dynamic sinkage and pitch

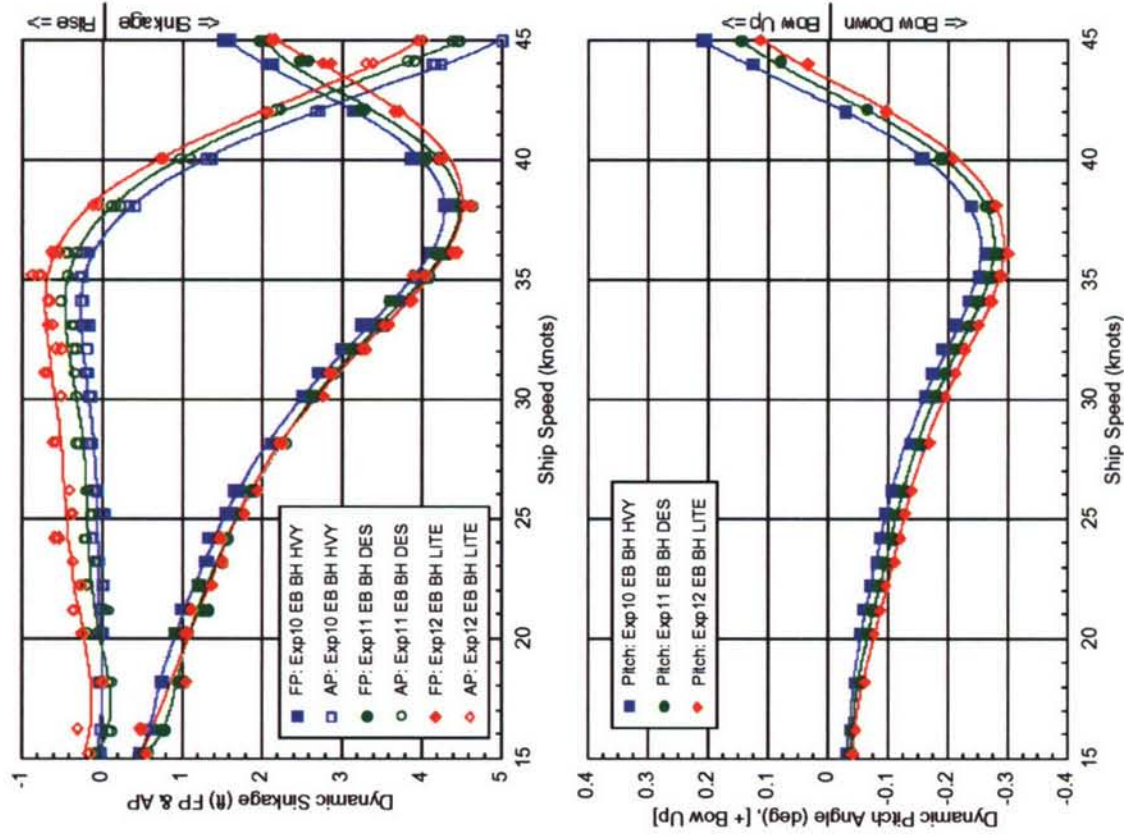


Fig B15. JHSS: BSS, EB, dynamic sinkage and pitch

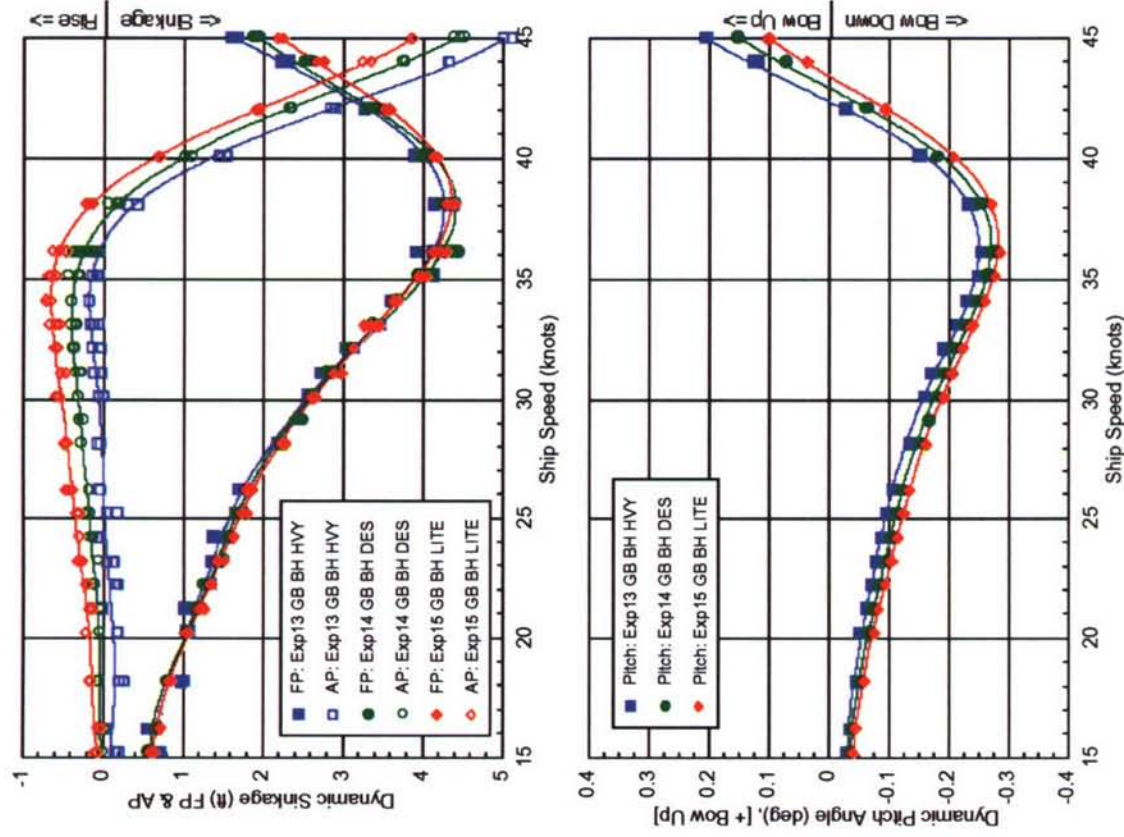


Fig B16. JHSS: BSS, GB, dynamic sinkage and pitch

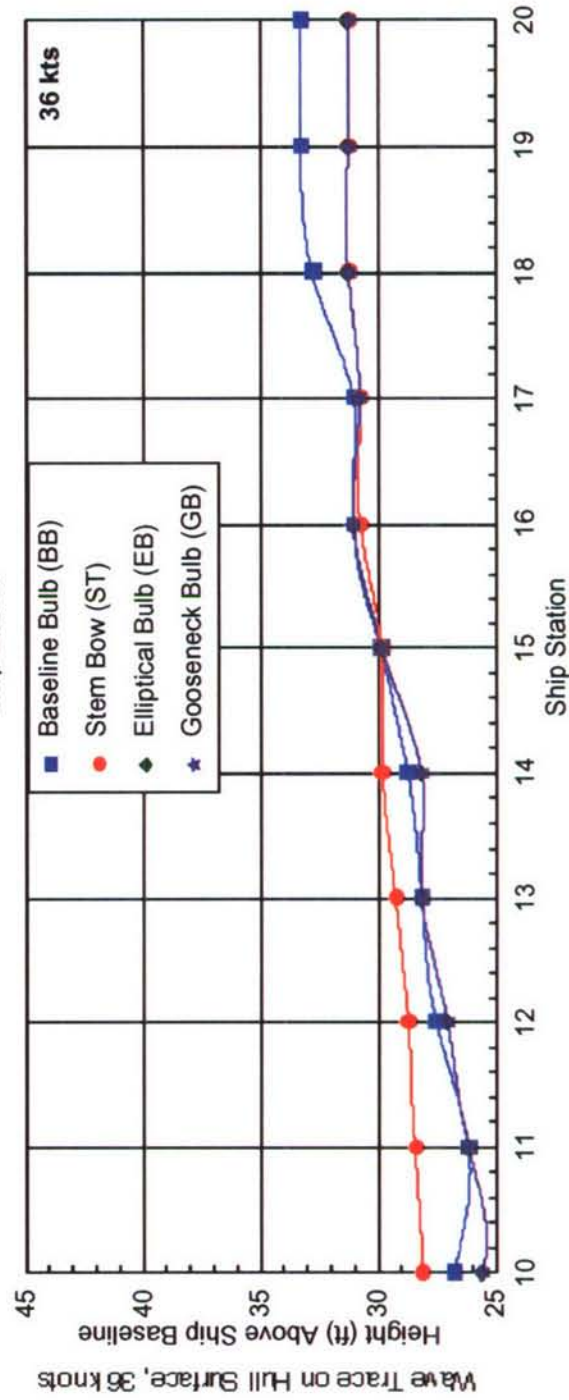
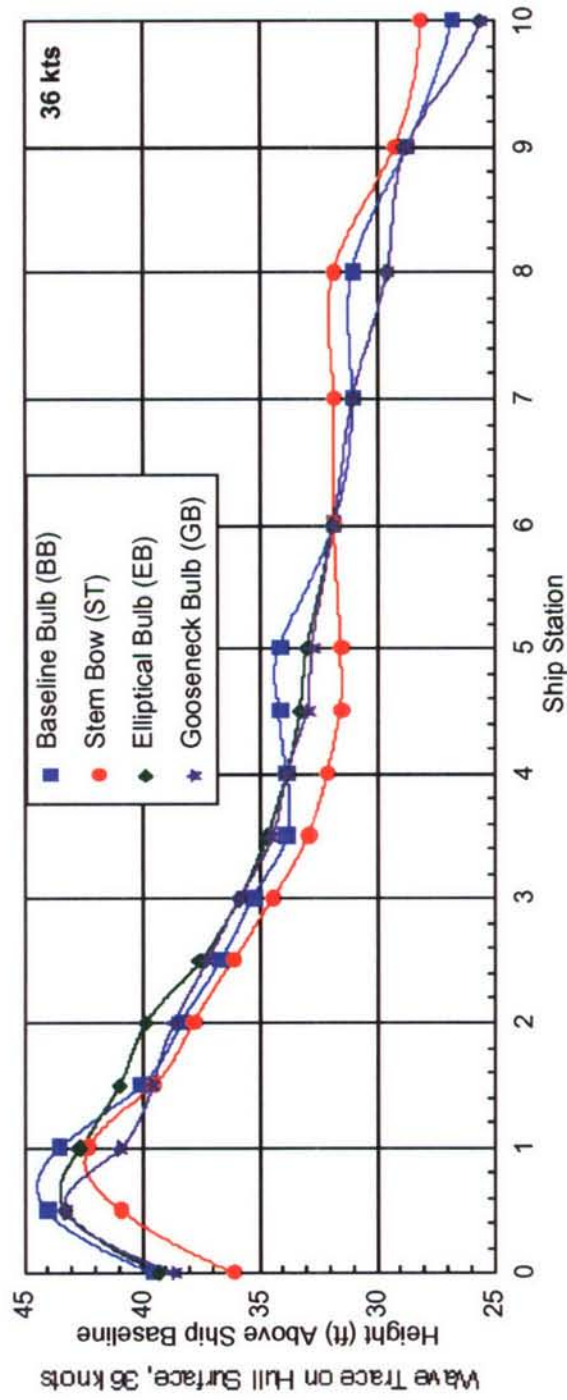


Fig B17. JHSS: BSS, bow variations, BH, DES, wave traces on hull surface, 36 knots

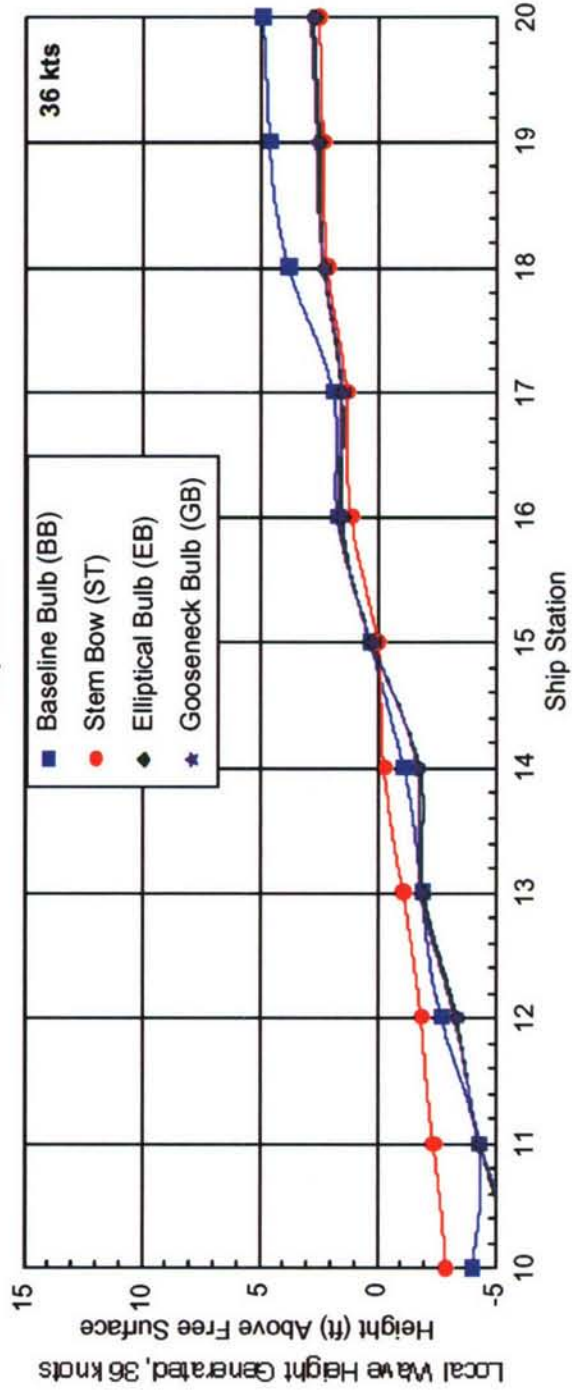
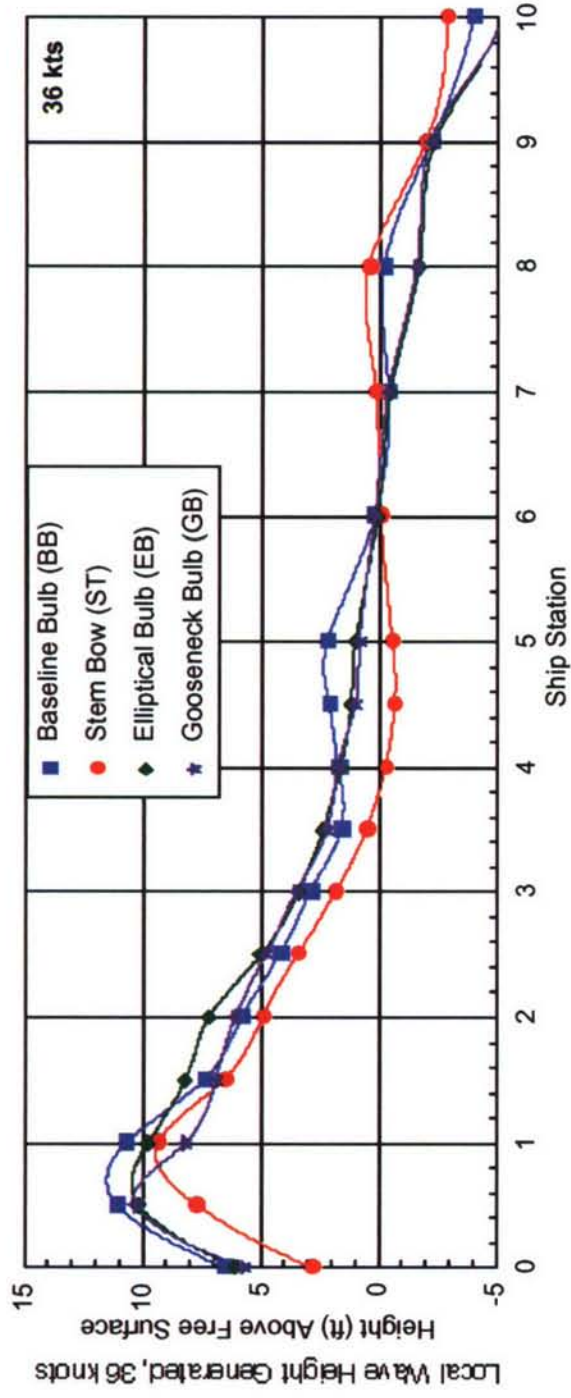


Fig B18. JHSS: BSS, bow variations, BH, DES, local wave heights generated, 36 knots

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Table B1. JHSS Series 1 Test Agenda

Test #	Test Type	Model Number	Stem	Bow	Propulsion	Appendages	Loading	Speeds (knots)	Comments	Figure & Table Description
-	PE set-up	5653	BSS	BB	n/a	FA	DES		Ballast model. Install model, hardware, software, electronics on Carriage. System check-outs.	n/a
1	Alignment	5653	BSS	BB	n/a	FA	DES	30	Check-out hardware, data collection, model alignment	n/a
2	Resistance	5653	BSS	BB	n/a	FA	DES	15-45	Fully appended baseline. 2-knot increments	Exp2 BSS BB FA DES
3	Resistance	5653	BSS	BB	n/a	S&S	DES	15-45	Remove Rudders	Exp3 BSS BB S&S (RUDoff) DES
-	Model Change	5653	BSS	BB	n/a	BH	HVY	-	Remove model, remove shaftlines, reballast, reinstall	n/a
4	Resistance	5653	BSS	BB	n/a	BH	HVY	15-45	Propulsion Shaftlines Removed	Exp4 BSS BB BH HVY
5	Resistance	5653	BSS	BB	n/a	BH	DES	15-45	Remove Ballast weights. Wave trace 36kts (Blue).	Exp5 BSS BB BH DES
6	Resistance	5653	BSS	BB	n/a	BH	LITE	15-45	Remove Ballast weights	Exp6 BSS BB BH LITE
-	Model Change	5653-1	BSS	ST	n/a	BH	HVY	-	Remove model, reconfigure bow, reballast, reinstall	n/a
7	Resistance	5653-1	BSS	ST	n/a	BH	HVY	15-45	Remove Ballast weights. Wave trace 36kts (Red).	Exp7 BSS ST BH HVY
8	Resistance	5653-1	BSS	ST	n/a	BH	DES	15-45	Remove Ballast weights	Exp8 BSS ST BH DES
9	Resistance	5653-1	BSS	ST	n/a	BH	LITE	15-45	Remove model, reconfigure bow, reballast, reinstall	Exp9 BSS ST BH LITE
-	Model Change	5653-2	BSS	EB	n/a	BH	HVY	-	Remove Ballast weights	n/a
10	Resistance	5653-2	BSS	EB	n/a	BH	HVY	15-45	Remove Ballast weights	Exp10 BSS EB BH HVY
11	Resistance	5653-2	BSS	EB	n/a	BH	DES	15-45	Remove Ballast weights. Wave trace 36kts (orange).	Exp11 BSS EB BH DES
12	Resistance	5653-2	BSS	EB	n/a	BH	LITE	15-45	Remove Ballast weights	Exp12 BSS EB BH LITE
-	Model Change	5653-3	BSS	GB	n/a	BH	HVY	-	Remove model, reconfigure bow, reballast, reinstall	n/a
13	Resistance	5653-3	BSS	GB	n/a	BH	HVY	15-45	Remove Ballast weights	Exp13 BSS GB BH HVY
14	Resistance	5653-3	BSS	GB	n/a	BH	DES	15-45	Remove Ballast weights. Wave trace 36kts (black).	Exp14 BSS GB BH DES
15	Resistance	5653-3	BSS	GB	n/a	BH	LITE	15-45	Remove Ballast weights	Exp15 BSS GB BH LITE
-	Bulb Selection	-	-	-	-	-	-	-	Bulb Selection	n/a
-	Model Change	5653-3	BSS	GB	n/a	FA	DES	-	Install shaftlines, rudders, reballast, reinstall	n/a
16	Resistance	5653-3	BSS	GB	n/a	FA	DES	15-45	Fully appended, selected bulb.	Exp16 BSS GB FA DES
17	Resistance	5653-3	BSS	GB	n/a	FA	DES	15-45	Completion of Test 16	Exp16&17 BSS GB FA DES

Notes:

Hullforms: Baseline Shaft & Strut (BSS), Baseline Bulb (BB), Stem Bow (ST), Elliptical Bulb (EB), Gooseneck Bulb (GB)

Loading Conditions: Design (DES), Heavy (HVY), Light (LITE)

Table B2. JHSS: Exp2, BSS, BB, FA, DES, PE prediction

JHSS Exp2 BSS BB FA DES (PE from CR input)							
SHIP			MODEL				
LAMBDA			34.121				
LWL	950.1	ft	27.845	ft			
S	106692	ft ²	91.641	ft ²			
WT	36491	LT	2000.6	lbs			
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec			
Ca			0.0000				
Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	7379.0	5502.5	4441.5	3312.0	0.145	0.487	0.938
16.0	8998.9	6710.4	5349.0	3988.7	0.154	0.519	0.960
17.0	10796.4	8050.9	6369.9	4750.0	0.164	0.552	0.971
18.0	12737.8	9498.6	7510.4	5600.5	0.174	0.584	0.966
19.0	14816.0	11048.3	8776.8	6544.9	0.183	0.616	0.949
20.0	17050.5	12714.5	10175.3	7587.7	0.193	0.649	0.926
21.0	19481.3	14527.2	11712.0	8733.6	0.203	0.681	0.904
22.0	22159.1	16524.0	13393.1	9987.2	0.212	0.714	0.887
23.0	25131.6	18740.6	15224.5	11352.9	0.222	0.746	0.877
24.0	28431.9	21201.7	17212.5	12835.4	0.232	0.779	0.874
25.0	32070.0	23914.6	19363.1	14439.0	0.241	0.811	0.876
26.0	36030.0	26867.6	21682.2	16168.4	0.251	0.844	0.879
27.0	40275.0	30033.0	24175.8	18027.9	0.261	0.876	0.881
28.0	44760.3	33377.7	26849.9	20022.0	0.270	0.908	0.879
29.0	49453.6	36877.6	29710.5	22155.1	0.280	0.941	0.872
30.0	54360.5	40536.6	32763.5	24431.7	0.290	0.973	0.862
31.0	59550.8	44407.0	36014.7	26856.2	0.299	1.006	0.851
32.0	65181.6	48605.9	39470.1	29432.8	0.309	1.038	0.845
33.0	71511.1	53325.8	43135.4	32166.1	0.319	1.071	0.851
34.0	78896.7	58833.2	47016.7	35060.3	0.328	1.103	0.874
35.0	87773.4	65452.6	51119.5	38119.8	0.338	1.135	0.921
36.0	98608.6	73532.4	55449.9	41349.0	0.348	1.168	0.997
37.0	111834.2	83394.8	60013.5	44752.1	0.357	1.200	1.102
38.0	127761.7	95271.9	64816.2	48333.4	0.367	1.233	1.236
39.0	146494.9	109241.3	69863.6	52097.3	0.376	1.265	1.392
40.0	167863.7	125176.0	75161.6	56048.0	0.386	1.298	1.560
41.0	191417.5	142740.1	80715.8	60189.8	0.396	1.330	1.730
42.0	216534.0	161469.4	86532.0	64526.9	0.405	1.363	1.890
43.0	242719.8	180996.2	92615.8	69063.6	0.415	1.395	2.034
44.0	270207.2	201493.5	98973.0	73804.2	0.425	1.427	2.166
45.0	300981.1	224441.6	105609.2	78752.8	0.434	1.460	2.310

Table B3. JHSS: Exp3, BSS, BB, S&S (RUDoff), DES, PE prediction

JHSS Exp3 BSS BB S&S (RUDoff) DES (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	950.1	ft	34.121	ft			
S	105069	ft ²	27.845	ft ²			
WT	36491	LT	90.247	lbs			
RHO	1.9905	(lbf*sec ²)/ft ⁴	2000.6	(lbf*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.9365	ft ² /sec			
Ca			1.0692E-05				
			0.0000				
Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	7267.8	5419.6	4373.9	3261.6	0.145	0.487	0.938
16.0	8851.8	6600.8	5267.6	3928.1	0.154	0.519	0.957
17.0	10580.9	7890.2	6273.0	4677.8	0.164	0.552	0.959
18.0	12452.6	9285.9	7396.2	5515.3	0.174	0.584	0.948
19.0	14454.2	10778.5	8643.3	6445.3	0.183	0.616	0.927
20.0	16600.7	12379.1	10020.5	7472.3	0.193	0.649	0.900
21.0	18929.9	14116.0	11533.8	8600.8	0.203	0.681	0.874
22.0	21491.7	16026.3	13189.3	9835.3	0.212	0.714	0.853
23.0	24335.2	18146.8	14992.9	11180.2	0.222	0.746	0.840
24.0	27496.1	20503.9	16950.7	12640.1	0.232	0.779	0.834
25.0	30986.9	23106.9	19068.5	14219.4	0.241	0.811	0.834
26.0	34793.2	25945.3	21352.3	15922.4	0.251	0.844	0.837
27.0	38878.1	28991.4	23808.0	17753.6	0.261	0.876	0.838
28.0	43193.6	32209.5	26441.5	19717.4	0.270	0.908	0.835
29.0	47701.6	35571.1	29258.6	21818.1	0.280	0.941	0.827
30.0	52398.7	39073.7	32265.1	24060.1	0.290	0.973	0.816
31.0	57343.9	42761.3	35466.8	26447.6	0.299	1.006	0.803
32.0	62683.3	46743.0	38869.7	28985.1	0.309	1.038	0.795
33.0	68666.0	51204.2	42479.3	31676.8	0.319	1.071	0.797
34.0	75644.5	56408.1	46301.4	34527.0	0.328	1.103	0.817
35.0	84055.9	62680.5	50341.9	37540.0	0.338	1.135	0.860
36.0	94378.7	70378.2	54606.4	40720.0	0.348	1.168	0.933
37.0	107065.4	79838.7	59100.6	44071.3	0.357	1.200	1.036
38.0	122456.9	91316.1	63830.2	47598.2	0.367	1.233	1.169
39.0	140690.1	104912.6	68800.8	51304.8	0.376	1.265	1.326
40.0	161623.8	120522.8	74018.2	55195.4	0.386	1.298	1.497
41.0	184816.8	137817.9	79487.9	59274.2	0.396	1.330	1.672
42.0	209615.7	156310.4	85215.6	63545.3	0.405	1.363	1.837
43.0	235424.6	175556.1	91206.9	68013.0	0.415	1.395	1.984
44.0	262260.3	195567.5	97467.4	72681.5	0.425	1.427	2.116
45.0	291725.3	217539.6	104002.7	77554.8	0.434	1.460	2.254

Table B4. JHSS: Exp4, BSS, BB, BH, HVY, PE prediction

JHSS Exp4 BSS BB BH HVY (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	949.1	ft	34.121	ft			
S	108594	ft ²	93.274	ft ²			
WT	40140	LT	2200.7	lbs			
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec			
Ca			0.0000				
Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	6222.3	4640.0	4521.2	3371.5	0.145	0.487	0.533
16.0	7604.3	5670.5	5445.0	4060.3	0.155	0.519	0.558
17.0	9104.3	6789.1	6484.2	4835.3	0.164	0.552	0.564
18.0	10708.6	7985.4	7645.3	5701.1	0.174	0.584	0.556
19.0	12428.0	9267.6	8934.4	6662.4	0.184	0.617	0.539
20.0	14294.8	10659.7	10358.0	7724.0	0.193	0.649	0.521
21.0	16354.7	12195.7	11922.3	8890.4	0.203	0.682	0.507
22.0	18654.6	13910.7	13633.5	10166.5	0.212	0.714	0.499
23.0	21230.8	15831.8	15497.8	11556.7	0.222	0.747	0.499
24.0	24098.5	17970.2	17521.5	13065.8	0.232	0.779	0.504
25.0	27245.5	20317.0	19710.7	14698.2	0.241	0.811	0.510
26.0	30633.9	22843.7	22071.4	16458.6	0.251	0.844	0.516
27.0	34208.2	25509.0	24609.8	18351.5	0.261	0.876	0.516
28.0	37912.0	28270.9	27331.9	20381.4	0.270	0.909	0.510
29.0	41711.4	31104.2	30243.8	22552.8	0.280	0.941	0.498
30.0	45622.5	34020.7	33351.6	24870.3	0.290	0.974	0.481
31.0	49738.3	37089.8	36661.2	27338.2	0.299	1.006	0.465
32.0	54251.0	40455.0	40178.5	29961.1	0.309	1.039	0.455
33.0	59463.8	44342.1	43909.7	32743.5	0.319	1.071	0.458
34.0	65785.2	49056.0	47860.6	35689.6	0.328	1.104	0.483
35.0	73703.4	54960.6	52037.1	38804.1	0.338	1.136	0.535
36.0	83735.5	62441.6	56445.2	42091.2	0.348	1.169	0.619
37.0	96355.4	71852.2	61090.7	45555.3	0.357	1.201	0.737
38.0	111904.4	83447.1	65979.5	49200.9	0.367	1.233	0.886
39.0	130501.3	97314.8	71117.5	53032.3	0.377	1.266	1.060
40.0	151975.2	113327.9	76510.6	57053.9	0.386	1.298	1.248
41.0	175860.6	131139.3	82164.5	61270.0	0.396	1.331	1.439
42.0	201509.2	150265.4	88085.0	65685.0	0.406	1.363	1.620
43.0	228395.2	170314.3	94278.0	70303.1	0.415	1.396	1.785
44.0	256715.9	191433.0	100749.3	75128.8	0.425	1.428	1.938
45.0	288420.0	215074.8	107504.6	80166.2	0.435	1.461	2.101

Table B5. JHSS: Exp5, BSS, BB, BH, DES, PE prediction

JHSS Exp5 BSS BB BH DES (PE from CR input)

SHIP			MODEL	
LAMBDA			34.121	
LWL	950.1	ft	27.845	ft
S	105069	ft ²	90.247	ft ²
WT	36491	LT	2000.6	lbs
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec
Ca			0.0000	

Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	5599.5	4175.6	4373.9	3261.6	0.145	0.487	0.397
16.0	6811.9	5079.6	5267.6	3928.1	0.154	0.519	0.412
17.0	8139.0	6069.2	6273.0	4677.8	0.164	0.552	0.415
18.0	9565.9	7133.3	7396.2	5515.3	0.174	0.584	0.407
19.0	11099.1	8276.6	8643.3	6445.3	0.183	0.616	0.392
20.0	12765.0	9518.8	10020.5	7472.3	0.193	0.649	0.375
21.0	14602.5	10889.1	11533.8	8600.8	0.203	0.681	0.362
22.0	16654.3	12419.1	13189.3	9835.3	0.212	0.714	0.356
23.0	18955.1	14134.8	14992.9	11180.2	0.222	0.746	0.356
24.0	21523.5	16050.1	16950.7	12640.1	0.232	0.779	0.362
25.0	24355.8	18162.1	19068.5	14219.4	0.241	0.811	0.370
26.0	27426.4	20451.8	21352.3	15922.4	0.251	0.844	0.378
27.0	30694.6	22889.0	23808.0	17753.6	0.261	0.876	0.383
28.0	34118.5	25442.2	26441.5	19717.4	0.270	0.908	0.383
29.0	37674.0	28093.5	29258.6	21818.1	0.280	0.941	0.377
30.0	41378.2	30855.7	32265.1	24060.1	0.290	0.973	0.369
31.0	45312.6	33789.6	35466.8	26447.6	0.299	1.006	0.362
32.0	49642.1	37018.1	38869.7	28985.1	0.309	1.038	0.360
33.0	54625.2	40734.0	42479.3	31676.8	0.319	1.071	0.370
34.0	60609.5	45196.5	46301.4	34527.0	0.328	1.103	0.398
35.0	68010.2	50715.2	50341.9	37540.0	0.338	1.135	0.451
36.0	77266.8	57617.8	54606.4	40720.0	0.348	1.168	0.531
37.0	88781.7	66204.5	59100.6	44071.3	0.357	1.200	0.641
38.0	102844.6	76691.2	63830.2	47598.2	0.367	1.233	0.778
39.0	119555.6	89152.6	68800.8	51304.8	0.376	1.265	0.936
40.0	138770.0	103480.8	74018.2	55195.4	0.386	1.298	1.107
41.0	160096.7	119384.1	79487.9	59274.2	0.396	1.330	1.279
42.0	182999.2	136462.5	85215.6	63545.3	0.405	1.363	1.444
43.0	207066.3	154409.4	91206.9	68013.0	0.415	1.395	1.594
44.0	232541.6	173406.3	97467.4	72681.5	0.425	1.427	1.735
45.0	261226.3	194796.5	104002.7	77554.8	0.434	1.460	1.887

Table B6. JHSS: Exp6, BSS, BB, BH, LITE, PE prediction

JHSS Exp6 BSS BB BH LITE (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	946.6	ft	34.121	ft			
S	98649	ft ²	84.732	ft ²			
WT	32841	LT	1800.5	lbs			
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec			
Ca			0.0000				
Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	5259.2	3921.8	4108.4	3063.7	0.145	0.488	0.397
16.0	6397.8	4770.9	4947.9	3689.7	0.155	0.520	0.412
17.0	7644.3	5700.3	5892.3	4393.9	0.164	0.553	0.415
18.0	8984.4	6699.7	6947.3	5180.6	0.174	0.585	0.407
19.0	10424.5	7773.5	8118.7	6054.1	0.184	0.618	0.392
20.0	11989.1	8940.2	9412.3	7018.8	0.193	0.650	0.375
21.0	13715.0	10227.3	10833.8	8078.7	0.203	0.683	0.362
22.0	15642.0	11664.2	12388.8	9238.3	0.213	0.715	0.356
23.0	17803.0	13275.7	14082.9	10501.6	0.222	0.748	0.356
24.0	20215.2	15074.5	15921.8	11872.9	0.232	0.780	0.362
25.0	22875.2	17058.1	17911.0	13356.3	0.242	0.813	0.370
26.0	25759.1	19208.6	20056.2	14955.9	0.251	0.845	0.378
27.0	28828.6	21497.5	22362.8	16675.9	0.261	0.878	0.383
28.0	32060.2	23907.3	24836.4	18520.5	0.271	0.910	0.383
29.0	35490.8	26465.5	27482.4	20493.7	0.280	0.943	0.383
30.0	39103.9	29159.8	30306.4	22599.5	0.290	0.975	0.380
31.0	42970.1	32042.8	33313.8	24842.1	0.300	1.008	0.378
32.0	47228.2	35218.1	36510.0	27225.5	0.309	1.040	0.381
33.0	52094.0	38846.5	39900.5	29753.8	0.319	1.073	0.395
34.0	57857.2	43144.1	43490.6	32430.9	0.329	1.105	0.426
35.0	64863.5	48368.7	47285.7	35261.0	0.338	1.138	0.478
36.0	73480.0	54794.0	51291.3	38247.9	0.348	1.170	0.554
37.0	84043.3	62671.1	55512.6	41395.7	0.358	1.203	0.656
38.0	96797.0	72181.5	59955.0	44708.5	0.368	1.235	0.782
39.0	111827.1	83389.5	64623.9	48190.0	0.377	1.268	0.927
40.0	129013.7	96205.5	69524.4	51844.4	0.387	1.300	1.083
41.0	148026.5	110383.3	74662.0	55675.5	0.397	1.333	1.240
42.0	168404.1	125578.9	80042.0	59687.3	0.406	1.365	1.390
43.0	189772.1	141513.0	85669.5	63883.7	0.416	1.398	1.526
44.0	212273.5	158292.4	91549.8	68268.7	0.426	1.430	1.651
45.0	237308.2	176960.7	97688.2	72846.1	0.435	1.463	1.785

Table B7. JHSS: Exp7, BSS, ST, BH, HVY, PE prediction

JHSS Exp7 BSS ST BH HVY (PE from CR input)

SHIP			MODEL	
LAMBDA			34.121	
LWL	948.4	ft	27.795	ft
S	107122	ft ²	92.010	ft ²
WT	40140	LT	2200.7	lbs
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec
Ca			0.0000	

Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	6001.6	4475.4	4460.3	3326.1	0.145	0.487	0.490
16.0	7330.0	5466.0	5371.7	4005.7	0.155	0.520	0.513
17.0	8910.7	6644.7	6396.9	4770.2	0.164	0.552	0.549
18.0	10700.2	7979.2	7542.3	5624.3	0.174	0.584	0.581
19.0	12681.5	9456.6	8814.1	6572.6	0.184	0.617	0.605
20.0	14856.0	11078.2	10218.5	7619.9	0.193	0.649	0.622
21.0	17233.8	12851.3	11761.7	8770.7	0.203	0.682	0.634
22.0	19850.7	14802.7	13449.8	10029.5	0.213	0.714	0.645
23.0	22727.8	16948.1	15289.1	11401.1	0.222	0.747	0.656
24.0	25866.1	19288.4	17285.5	12889.8	0.232	0.779	0.666
25.0	29260.2	21819.3	19445.1	14500.2	0.242	0.812	0.674
26.0	32880.1	24518.7	21774.0	16236.9	0.251	0.844	0.678
27.0	36660.7	27337.9	24278.2	18104.3	0.261	0.877	0.675
28.0	40569.0	30252.3	26963.7	20106.8	0.271	0.909	0.665
29.0	44565.6	33232.6	29836.4	22249.0	0.280	0.942	0.648
30.0	48679.9	36300.6	32902.3	24535.2	0.290	0.974	0.627
31.0	53020.6	39537.4	36167.3	26969.9	0.300	1.007	0.607
32.0	57777.7	43084.8	39637.3	29557.5	0.309	1.039	0.594
33.0	63279.9	47187.8	43318.1	32302.3	0.319	1.072	0.596
34.0	69927.0	52144.5	47215.8	35208.8	0.329	1.104	0.620
35.0	78308.4	58394.6	51336.0	38281.3	0.338	1.137	0.675
36.0	88905.6	66296.9	55684.7	41524.1	0.348	1.169	0.764
37.0	102282.8	76272.3	60267.6	44941.6	0.357	1.201	0.890
38.0	118736.6	88541.9	65090.6	48538.1	0.367	1.234	1.049
39.0	138491.3	103272.9	70159.4	52317.8	0.377	1.266	1.236
40.0	161252.6	120246.1	75479.7	56285.2	0.386	1.299	1.438
41.0	186464.9	139046.9	81057.4	60444.5	0.396	1.331	1.641
42.0	213465.5	159181.2	86898.2	64800.0	0.406	1.364	1.833
43.0	241281.3	179923.5	93007.8	69355.9	0.415	1.396	2.001
44.0	269843.5	201222.3	99391.9	74116.5	0.425	1.429	2.147
45.0	300710.1	224239.5	106056.1	79086.1	0.435	1.461	2.292

Table B8. JHSS: Exp8, BSS, ST, BH, DES, PE prediction

JHSS Exp8 BSS ST BH DES (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	949	ft	34.121	ft			
S	103623	ft ²	89.005	ft ²			
WT	36491	LT	2000.6	lbs			
RHO	1.9905	(lb*sec ²)/ft ⁴	1.9365	(lb*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec			
Ca			0.0000				
Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15.0	5266.7	3927.4	4314.3	3217.2	0.145	0.487	0.313
16.0	6396.0	4769.5	5195.8	3874.5	0.155	0.519	0.325
17.0	7706.7	5746.9	6187.5	4614.0	0.164	0.552	0.343
18.0	9225.0	6879.1	7295.4	5440.2	0.174	0.584	0.367
19.0	10918.6	8142.0	8525.5	6357.5	0.184	0.617	0.387
20.0	12797.8	9543.3	9884.0	7370.5	0.193	0.649	0.404
21.0	14866.6	11086.1	11376.7	8483.6	0.203	0.682	0.418
22.0	17175.8	12808.0	13009.6	9701.2	0.212	0.714	0.434
23.0	19735.7	14716.9	14788.6	11027.9	0.222	0.747	0.451
24.0	22589.7	16845.2	16719.7	12467.9	0.232	0.779	0.471
25.0	25711.1	19172.8	18808.6	14025.6	0.241	0.812	0.490
26.0	29063.3	21672.5	21061.3	15705.4	0.251	0.844	0.505
27.0	32604.5	24313.2	23483.5	17511.7	0.261	0.876	0.514
28.0	36273.3	27049.0	26081.1	19448.7	0.270	0.909	0.515
29.0	39985.6	29817.2	28859.7	21520.7	0.280	0.941	0.506
30.0	43777.1	32644.6	31825.3	23732.1	0.290	0.974	0.491
31.0	47714.1	35580.4	34983.4	26087.1	0.299	1.006	0.474
32.0	51988.1	38767.6	38339.8	28590.0	0.309	1.039	0.462
33.0	56933.3	42455.1	41900.2	31245.0	0.319	1.071	0.464
34.0	62891.4	46898.1	45670.3	34056.3	0.328	1.104	0.486
35.0	70451.4	52535.6	49655.6	37028.2	0.338	1.136	0.538
36.0	80067.0	59705.9	53862.0	40164.9	0.348	1.169	0.623
37.0	92270.5	68806.1	58294.9	43470.5	0.357	1.201	0.744
38.0	107334.3	80039.2	62960.0	46949.3	0.367	1.234	0.897
39.0	125245.7	93395.7	67862.9	50605.3	0.377	1.266	1.073
40.0	145767.6	108698.9	73009.1	54442.9	0.386	1.298	1.261
41.0	168190.1	125419.4	78404.2	58466.0	0.396	1.331	1.445
42.0	191725.5	142969.7	84053.8	62678.9	0.406	1.363	1.612
43.0	215904.0	160999.6	89963.4	67085.7	0.415	1.396	1.757
44.0	241439.3	180041.3	96138.5	71690.5	0.425	1.428	1.892
45.0	271492.3	202451.8	102584.7	76497.4	0.435	1.461	2.056

Table B9. JHSS: Exp9, BSS, ST, BH, LITE, PE prediction

JHSS Exp9 BSS ST BH LITE (PE from CR input)

LAMBDA	SHIP		MODEL	
LWL	944.7	ft	34.121	ft
S	97488	ft ²	27.687	ft ²
WT	32841	LT	83.735	ft ²
RHO	1.9905	(lbf*sec ²)/ft ⁴	1800.5	lbs
NU	1.2817E-05	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴
Ca		ft ² /sec	1.0692E-05	ft ² /sec
			0.0000	

Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	4829.4	3601.3	4061.1	3028.3	0.145	0.488	0.268
16.0	5872.7	4379.2	4890.8	3647.1	0.155	0.521	0.283
17.0	7068.9	5271.3	5824.3	4343.2	0.165	0.553	0.299
18.0	8428.8	6285.3	6867.1	5120.8	0.174	0.586	0.316
19.0	9972.0	7436.1	8025.1	5984.3	0.184	0.618	0.335
20.0	11724.3	8742.8	9303.7	6937.8	0.194	0.651	0.357
21.0	13711.9	10225.0	10708.8	7985.5	0.203	0.683	0.382
22.0	15955.4	11897.9	12245.8	9131.7	0.213	0.716	0.411
23.0	18463.3	13768.1	13920.4	10380.4	0.223	0.748	0.440
24.0	21228.6	15830.2	15738.1	11735.9	0.232	0.781	0.468
25.0	24227.5	18066.4	17704.4	13202.1	0.242	0.813	0.492
26.0	27422.8	20449.2	19824.8	14783.3	0.252	0.846	0.510
27.0	30772.5	22947.1	22104.7	16483.5	0.261	0.878	0.519
28.0	34242.3	25534.4	24549.8	18306.8	0.271	0.911	0.521
29.0	37821.6	28203.6	27165.3	20257.1	0.281	0.944	0.515
30.0	41542.5	30978.3	29956.6	22338.7	0.290	0.976	0.506
31.0	45496.9	33927.0	32929.3	24555.4	0.300	1.009	0.497
32.0	49850.3	37173.4	36088.6	26911.3	0.310	1.041	0.495
33.0	54848.2	40900.3	39439.9	29410.3	0.319	1.074	0.506
34.0	60812.0	45347.5	42988.6	32056.6	0.329	1.106	0.535
35.0	68119.7	50796.9	46739.9	34853.9	0.339	1.139	0.588
36.0	77172.2	57547.3	50699.2	37806.4	0.349	1.171	0.669
37.0	88342.2	65876.8	54871.8	40917.9	0.358	1.204	0.779
38.0	101910.6	75994.7	59262.9	44192.3	0.368	1.236	0.916
39.0	117996.9	87990.3	63877.8	47633.7	0.378	1.269	1.076
40.0	136495.7	101784.9	68721.8	51245.8	0.387	1.301	1.249
41.0	157040.0	117104.7	73800.1	55032.7	0.397	1.334	1.424
42.0	179018.9	133494.4	79117.8	58998.2	0.407	1.366	1.590
43.0	201690.9	150400.9	84680.3	63146.1	0.416	1.399	1.735
44.0	224445.5	167369.0	90492.8	67480.5	0.426	1.432	1.854
45.0	250984.9	187159.5	96560.3	72005.0	0.436	1.464	1.998

Table B10. JHSS: Exp10, BSS, EB, BH, HVY, PE prediction

JHSS Exp10 BSS EB BH HVY (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	948.6	ft	34.121	27.801	ft		
S	108734	ft ²	93.395	93.395	ft ²		
WT	40140	LT	2200.7	2200.7	lbs		
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	1.9365	(lbf*sec ²)/ft ⁴		
NU	1.2817E-05	ft ² /sec	1.0692E-05	1.0692E-05	ft ² /sec		
Ca			0.0000				
Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	5756.5	4292.7	4527.3	3376.0	0.145	0.487	0.385
16.0	7033.3	5244.7	5452.4	4065.8	0.155	0.519	0.408
17.0	8482.2	6325.2	6493.0	4841.8	0.164	0.552	0.428
18.0	10077.6	7514.9	7655.6	5708.8	0.174	0.584	0.439
19.0	11814.5	8810.1	8946.5	6671.4	0.184	0.617	0.442
20.0	13694.4	10211.9	10372.0	7734.4	0.193	0.649	0.439
21.0	15767.0	11757.4	11938.4	8902.4	0.203	0.682	0.437
22.0	18064.0	13470.3	13651.9	10180.2	0.213	0.714	0.438
23.0	20629.3	15383.3	15518.8	11572.4	0.222	0.747	0.444
24.0	23456.3	17491.4	17545.2	13083.4	0.232	0.779	0.452
25.0	26581.1	19821.5	19737.3	14718.1	0.242	0.812	0.463
26.0	29949.2	22333.1	22101.2	16480.8	0.251	0.844	0.472
27.0	33506.3	24985.6	24643.0	18376.3	0.261	0.877	0.476
28.0	37233.1	27764.7	27368.8	20408.9	0.271	0.909	0.475
29.0	41082.5	30635.2	30284.7	22583.3	0.280	0.942	0.468
30.0	45069.5	33608.3	33396.6	24903.8	0.290	0.974	0.457
31.0	49280.1	36748.2	36710.6	27375.1	0.299	1.007	0.446
32.0	53903.3	40195.7	40232.8	30001.6	0.309	1.039	0.441
33.0	59199.6	44145.1	43968.9	32787.6	0.319	1.071	0.448
34.0	65623.9	48935.7	47925.1	35737.8	0.328	1.104	0.476
35.0	73720.4	54973.3	52107.3	38856.4	0.338	1.136	0.533
36.0	83758.6	62458.8	56521.3	42147.9	0.348	1.169	0.617
37.0	96339.5	71840.4	61173.1	45616.8	0.357	1.201	0.734
38.0	111896.9	83441.5	66068.5	49267.3	0.367	1.234	0.883
39.0	130505.4	97317.9	71213.5	53103.9	0.377	1.266	1.057
40.0	151994.0	113341.9	76613.8	57130.9	0.386	1.299	1.245
41.0	175902.9	131170.8	82275.3	61352.7	0.396	1.331	1.436
42.0	201536.6	150285.9	88203.8	65773.6	0.406	1.364	1.617
43.0	227943.1	169977.1	94405.2	70397.9	0.415	1.396	1.775
44.0	255689.5	190667.7	100885.2	75230.1	0.425	1.429	1.921
45.0	285836.5	213148.3	107649.6	80274.3	0.435	1.461	2.067

Table B11. JHSS: Exp11, BSS, EB, BH, DES, PE prediction

JHSS Exp11 BSS EB BH DES (PE from CR input)

LAMBDA	SHIP		MODEL			
	LWL					
S	949.4	ft	34.121	ft		
WT	105217	ft ²	27.825	ft ²		
RHO	36491	LT	90.374	lbs		
NU	1.9905	(lb*sec ²)/ft ⁴	2000.6	(lb*sec ²)/ft ⁴		
Ca	1.2817E-05	ft ² /sec	1.9365	ft ² /sec		
			1.0692E-05	ft ² /sec		
			0.0000			
Vs	PE		FRICTIONAL POWER	FN	V-L	1000CR
knots	HP	KW	HP	KW		
15.0	5155.9	3844.7	4380.4	3266.5	0.145	0.251
16.0	6274.0	4678.5	5275.5	3933.9	0.155	0.266
17.0	7522.7	5609.7	6282.4	4684.8	0.164	0.276
18.0	8888.5	6628.1	7407.2	5523.6	0.174	0.277
19.0	10378.7	7739.4	8656.2	6455.0	0.183	0.274
20.0	12019.9	8963.3	10035.5	7483.5	0.193	0.271
21.0	13851.6	10329.2	11551.1	8613.6	0.203	0.271
22.0	15915.9	11868.5	13209.0	9850.0	0.212	0.278
23.0	18247.0	13606.8	15015.4	11196.9	0.222	0.290
24.0	20861.5	15556.4	16976.0	12659.0	0.232	0.307
25.0	23752.7	17712.4	19097.0	14240.6	0.241	0.325
26.0	26890.9	20052.6	21384.2	15946.2	0.251	0.342
27.0	30230.0	22542.5	23843.6	17780.2	0.261	0.354
28.0	33721.4	25146.1	26481.0	19746.9	0.270	0.360
29.0	37334.5	27840.3	29302.3	21850.7	0.280	0.360
30.0	41080.2	30633.5	32313.3	24096.0	0.290	0.355
31.0	45035.5	33583.0	35519.8	26487.1	0.299	0.349
32.0	49364.0	36810.7	38927.7	29028.4	0.309	0.348
33.0	54326.3	40511.1	42542.7	31724.1	0.319	0.358
34.0	60277.5	44949.0	46370.6	34578.5	0.328	0.387
35.0	67644.7	50442.6	50417.1	37596.0	0.338	0.439
36.0	76883.2	57331.8	54687.9	40780.8	0.348	0.520
37.0	88412.9	65929.5	59188.8	44137.1	0.357	0.630
38.0	102537.6	76462.3	63925.4	47669.2	0.367	0.769
39.0	119362.6	89008.7	68903.5	51381.3	0.377	0.929
40.0	138729.5	103450.6	74128.6	55277.7	0.386	1.103
41.0	160111.1	119394.8	79606.5	59362.6	0.396	1.276
42.0	183073.3	136517.7	85342.8	63640.1	0.406	1.441
43.0	207023.1	154377.1	91343.0	68114.5	0.415	1.589
44.0	231809.5	172860.3	97612.8	72789.9	0.425	1.721
45.0	258970.7	193114.4	104157.8	77670.5	0.435	1.856

Table B12. JHSS: Exp12, BSS, EB, BH, LITE, PE prediction

JHSS Exp12 BSS EB BH LITE (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	946	ft	34.121	ft			
S	98895	ft ²	84.944	ft ²			
WT	32841	LT	1800.5	lbs			
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec			
Ca			0.0000				
Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	4728.8	3526.3	4119.0	3071.5	0.145	0.488	0.210
16.0	5736.0	4277.3	4960.6	3699.1	0.155	0.520	0.220
17.0	6888.0	5136.4	5907.4	4405.1	0.164	0.553	0.232
18.0	8206.8	6119.8	6965.1	5193.9	0.174	0.585	0.247
19.0	9658.5	7202.4	8139.6	6069.7	0.184	0.618	0.257
20.0	11247.6	8387.4	9436.5	7036.8	0.193	0.650	0.263
21.0	12995.6	9690.8	10861.6	8099.5	0.203	0.683	0.268
22.0	14934.0	11136.3	12420.6	9262.0	0.213	0.715	0.274
23.0	17095.8	12748.3	14119.0	10528.6	0.223	0.748	0.284
24.0	19505.7	14545.4	15962.7	11903.4	0.232	0.780	0.298
25.0	22173.5	16534.8	17957.0	13390.5	0.242	0.813	0.314
26.0	25091.0	18710.3	20107.7	14994.3	0.252	0.845	0.330
27.0	28234.8	21054.7	22420.2	16718.8	0.261	0.878	0.343
28.0	31575.9	23546.1	24900.1	18568.0	0.271	0.910	0.353
29.0	35093.8	26169.4	27553.0	20546.3	0.281	0.943	0.359
30.0	38796.7	28930.7	30384.2	22657.5	0.290	0.975	0.362
31.0	42742.2	31872.9	33399.3	24905.9	0.300	1.008	0.364
32.0	47055.8	35089.5	36603.7	27295.4	0.310	1.040	0.371
33.0	51907.3	38707.3	40002.9	29830.1	0.319	1.073	0.385
34.0	57670.3	43004.8	43602.2	32514.1	0.329	1.105	0.416
35.0	64655.4	48213.6	47407.1	35351.4	0.339	1.138	0.468
36.0	73218.3	54598.9	51422.9	38346.0	0.348	1.170	0.543
37.0	83765.7	62464.1	55655.0	41502.0	0.358	1.203	0.645
38.0	96516.2	71972.2	60108.8	44823.2	0.368	1.235	0.771
39.0	111642.4	83251.7	64789.7	48313.6	0.377	1.268	0.918
40.0	129013.5	96205.4	69702.8	51977.4	0.387	1.301	1.077
41.0	148208.3	110518.9	74853.6	55818.3	0.397	1.333	1.237
42.0	168663.3	125772.3	80247.3	59840.4	0.406	1.366	1.387
43.0	190007.5	141688.6	85889.2	64047.6	0.416	1.398	1.522
44.0	211912.5	158023.2	91784.6	68443.8	0.426	1.431	1.639
45.0	236715.8	176519.0	97938.8	73033.0	0.435	1.463	1.770

Table B13. JHSS: Exp13, BSS, GB, BH, HVY, PE prediction

JHSS Exp13 BSS GB BH HVY (PE from CR input)

LAMBDA	SHIP		MODEL	
LWL	947.9	ft	34.121	ft
S	108840	ft ²	93.486	ft ²
WT	40140	LT	2200.7	lbs
RHO	1.9905	(lb*sec ²)/ft ⁴	1.9365	(lb*sec ²)/ft ⁴
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec
Ca			0.0000	

Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	6082.1	4535.4	4532.1	3379.6	0.145	0.487	0.485
16.0	7358.4	5487.1	5458.2	4070.2	0.155	0.520	0.490
17.0	8742.1	6519.0	6499.9	4847.0	0.164	0.552	0.482
18.0	10235.2	7632.4	7663.7	5714.8	0.174	0.585	0.466
19.0	11856.9	8841.7	8956.0	6678.5	0.184	0.617	0.447
20.0	13640.7	10171.9	10383.0	7742.6	0.193	0.650	0.430
21.0	15626.7	11652.8	11951.0	8911.9	0.203	0.682	0.419
22.0	17853.3	13313.2	13666.4	10191.0	0.213	0.715	0.415
23.0	20347.9	15173.4	15535.2	11584.6	0.222	0.747	0.418
24.0	23120.0	17240.6	17563.8	13097.3	0.232	0.780	0.424
25.0	26157.7	19505.8	19758.2	14733.7	0.242	0.812	0.433
26.0	29430.0	21945.9	22124.6	16498.3	0.251	0.844	0.439
27.0	32894.3	24529.2	24669.1	18395.8	0.261	0.877	0.441
28.0	36510.4	27225.8	27397.8	20430.5	0.271	0.909	0.438
29.0	40259.8	30021.7	30316.7	22607.2	0.280	0.942	0.431
30.0	44167.3	32935.6	33432.0	24930.2	0.290	0.974	0.420
31.0	48323.7	36035.0	36749.5	27404.1	0.300	1.007	0.410
32.0	52904.4	39450.8	40275.4	30033.3	0.309	1.039	0.407
33.0	58179.9	43384.7	44015.5	32822.4	0.319	1.072	0.416
34.0	64514.7	48108.6	47975.9	35775.6	0.329	1.104	0.444
35.0	72349.5	53951.0	52162.5	38897.6	0.338	1.137	0.497
36.0	82164.1	61269.7	56581.1	42192.6	0.348	1.169	0.579
37.0	94421.6	70410.2	61237.8	45665.1	0.358	1.202	0.692
38.0	109496.5	81651.5	66138.4	49319.4	0.367	1.234	0.834
39.0	127593.1	95146.2	71288.8	53160.1	0.377	1.267	1.002
40.0	148672.6	110865.1	76694.8	57191.3	0.387	1.299	1.188
41.0	172407.2	128564.1	82362.3	61417.6	0.396	1.332	1.380
42.0	198200.9	147798.4	88297.1	65843.2	0.406	1.364	1.567
43.0	225319.4	168020.7	94505.0	70472.4	0.416	1.397	1.738
44.0	252801.3	188513.9	100991.9	75309.6	0.425	1.429	1.882
45.0	282499.9	210660.2	107763.4	80359.2	0.435	1.462	2.025

Table B14. JHSS: Exp14, BSS, GB, BH, DES, PE prediction

JHSS Exp14 BSS GB BH DES (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	977.9	ft	34.121	ft			
S	105221	ft ²	28.660	ft ²			
WT	36491	LT	90.377	lbs			
RHO	1.9905	(lbf*sec ²)/ft ⁴	2000.6	(lbf*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.9365	ft ² /sec			
Ca			1.0692E-05				
			0.0000				
Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15.0	5593.8	4171.3	4365.2	3255.1	0.143	0.480	0.398
16.0	6624.1	4939.6	5257.2	3920.3	0.152	0.512	0.365
17.0	7787.7	5807.3	6260.6	4668.6	0.162	0.544	0.340
18.0	9079.3	6770.4	7381.7	5504.5	0.171	0.576	0.318
19.0	10509.3	7836.8	8626.5	6432.8	0.181	0.608	0.300
20.0	12101.8	9024.3	10001.1	7457.8	0.190	0.640	0.287
21.0	13889.4	10357.4	11511.6	8584.2	0.200	0.672	0.280
22.0	15905.2	11860.5	13164.0	9816.4	0.209	0.704	0.281
23.0	18174.3	13552.6	14964.3	11158.9	0.219	0.735	0.288
24.0	20706.8	15441.1	16918.5	12616.1	0.228	0.767	0.299
25.0	23494.0	17519.4	19032.4	14192.5	0.238	0.799	0.312
26.0	26509.4	19768.1	21312.1	15892.4	0.247	0.831	0.323
27.0	29716.0	22159.2	23763.3	17720.3	0.257	0.863	0.330
28.0	33078.4	24666.6	26392.0	19680.5	0.266	0.895	0.333
29.0	36581.0	27278.4	29204.0	21777.4	0.276	0.927	0.330
30.0	40248.2	30013.1	32205.2	24015.4	0.285	0.959	0.325
31.0	44165.6	32934.3	35401.2	26398.7	0.295	0.991	0.321
32.0	48496.3	36163.7	38797.9	28931.6	0.304	1.023	0.323
33.0	53489.6	39887.2	42401.1	31618.5	0.314	1.055	0.337
34.0	59477.6	44352.5	46216.5	34463.7	0.324	1.087	0.369
35.0	66854.8	49853.6	50249.9	37471.3	0.333	1.119	0.423
36.0	76039.5	56702.6	54506.9	40645.8	0.343	1.151	0.504
37.0	87417.8	65187.5	58993.2	43991.2	0.352	1.183	0.613
38.0	101273.9	75519.9	63714.5	47511.9	0.362	1.215	0.748
39.0	117717.2	87781.8	68676.4	51212.0	0.371	1.247	0.903
40.0	136625.5	101881.6	73884.7	55095.8	0.381	1.279	1.071
41.0	157629.4	117544.2	79344.9	59167.5	0.390	1.311	1.241
42.0	180181.9	134361.6	85062.7	63431.3	0.400	1.343	1.402
43.0	203766.4	151948.6	91043.6	67891.2	0.409	1.375	1.549
44.0	228319.8	170258.1	97293.3	72551.6	0.419	1.407	1.680
45.0	254967.6	190129.4	103817.3	77416.6	0.428	1.439	1.812

Table B15. JHSS: Exp15, BSS, GB, BH, LITE, PE prediction

JHSS Exp15 BSS GB BH LITE (PE from CR input)

SHIP			MODEL				
LAMBDA			34.121				
LWL	976.4	ft	28.616	ft			
S	98550	ft ²	84.647	ft ²			
WT	32841	LT	1800.5	lbs			
RHO	1.9905	(lb*sec ²)/ft ⁴	1.9365	(lb*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec			
Ca			0.0000				
Vs	PE		FRICTIONAL POWER		FN	V-L	1000CR
knots	HP	KW	HP	KW			
15.0	5405.4	4030.8	4089.2	3049.3	0.143	0.480	0.455
16.0	6389.2	4764.4	4924.8	3672.4	0.152	0.512	0.417
17.0	7504.7	5596.2	5864.8	4373.4	0.162	0.544	0.389
18.0	8740.0	6517.4	6914.9	5156.5	0.171	0.576	0.365
19.0	10099.8	7531.4	8081.0	6026.0	0.181	0.608	0.343
20.0	11604.3	8653.3	9368.7	6986.3	0.190	0.640	0.326
21.0	13285.5	9907.0	10783.7	8041.4	0.200	0.672	0.315
22.0	15179.4	11319.3	12331.6	9195.7	0.209	0.704	0.312
23.0	17317.9	12914.0	14018.1	10453.3	0.219	0.736	0.316
24.0	19720.6	14705.6	15848.7	11818.4	0.229	0.768	0.327
25.0	22389.5	16695.8	17828.9	13295.0	0.238	0.800	0.340
26.0	25308.2	18872.3	19964.4	14887.5	0.248	0.832	0.355
27.0	28446.1	21212.3	22260.7	16599.8	0.257	0.864	0.367
28.0	31768.5	23689.8	24723.1	18436.0	0.267	0.896	0.374
29.0	35251.7	26287.2	27357.3	20400.4	0.276	0.928	0.378
30.0	38901.7	29009.0	30168.7	22496.8	0.286	0.960	0.377
31.0	42774.2	31896.7	33162.6	24729.3	0.295	0.992	0.376
32.0	46992.1	35042.0	36344.5	27102.1	0.305	1.024	0.379
33.0	51756.7	38595.0	39719.9	29619.1	0.314	1.056	0.391
34.0	57347.8	42764.3	43294.0	32284.3	0.324	1.088	0.417
35.0	64110.5	47807.2	47072.2	35101.8	0.333	1.120	0.463
36.0	72423.6	54006.3	51060.0	38075.4	0.343	1.152	0.534
37.0	82652.0	61633.6	55262.6	41209.3	0.352	1.184	0.631
38.0	95083.5	70903.8	59685.3	44507.3	0.362	1.216	0.752
39.0	109860.1	81922.6	64333.5	47973.5	0.371	1.248	0.895
40.0	126916.9	94642.0	69212.4	51611.7	0.381	1.280	1.052
41.0	145953.9	108837.8	74327.3	55425.9	0.390	1.312	1.212
42.0	166472.9	124138.9	79683.5	59420.0	0.400	1.344	1.366
43.0	187930.7	140139.9	85286.2	63597.9	0.409	1.376	1.506
44.0	210072.8	156651.3	91140.6	67963.6	0.419	1.408	1.628
45.0	233533.6	174146.0	97252.0	72520.8	0.429	1.440	1.744

Table B16. JHSS: Exp16&17, BSS, GB, FA, DES, PE prediction

JHSS Exp16&17 BSS GB FA DES (PE from CR input)							
LAMBDA	SHIP		MODEL				
LWL	977.9	ft	34.121	ft			
S	106845	ft ²	91.772	ft ²			
WT	36491	LT	2000.6	lbs			
RHO	1.9905	(lbf*sec ²)/ft ⁴	1.9365	(lbf*sec ²)/ft ⁴			
NU	1.2817E-05	ft ² /sec	1.0692E-05	ft ² /sec			
Ca			0.0000				
Vs knots	PE		FRICTIONAL POWER		FN	V-L	1000CR
	HP	KW	HP	KW			
15.0	7631.1	5690.5	4432.5	3305.3	0.143	0.480	1.020
16.0	9068.5	6762.4	5338.3	3980.8	0.152	0.512	0.980
17.0	10714.3	7989.7	6357.3	4740.6	0.162	0.544	0.954
18.0	12557.9	9364.4	7495.6	5589.5	0.171	0.576	0.934
19.0	14575.5	10869.0	8759.6	6532.1	0.181	0.608	0.912
20.0	16767.3	12503.4	10155.5	7572.9	0.190	0.640	0.889
21.0	19161.8	14288.9	11689.3	8716.7	0.200	0.672	0.868
22.0	21820.2	16271.4	13367.2	9967.9	0.209	0.704	0.854
23.0	24809.0	18500.0	15195.3	11331.1	0.219	0.735	0.850
24.0	28153.9	20994.4	17179.6	12810.8	0.228	0.767	0.854
25.0	31885.6	23777.1	19326.2	14411.5	0.238	0.799	0.865
26.0	35941.6	26801.6	21641.0	16137.7	0.247	0.831	0.875
27.0	40217.7	29990.3	24130.1	17993.8	0.257	0.863	0.879
28.0	44711.3	33341.2	26799.4	19984.3	0.266	0.895	0.878
29.0	49489.5	36904.3	29654.8	22113.6	0.276	0.927	0.875
30.0	54424.4	40584.3	32702.2	24386.0	0.285	0.959	0.865
31.0	59747.4	44553.6	35947.6	26806.1	0.295	0.991	0.859
32.0	65303.2	48696.6	39396.8	29378.2	0.304	1.023	0.850
33.0	71535.2	53343.8	43055.6	32106.5	0.314	1.055	0.853
34.0	78801.6	58762.4	46929.9	34995.6	0.324	1.087	0.872
35.0	87334.0	65125.0	51025.4	38049.7	0.333	1.119	0.911
36.0	98111.4	73161.7	55348.1	41273.1	0.343	1.151	0.986
37.0	111368.7	83047.6	59903.7	44670.2	0.352	1.183	1.093
38.0	127404.4	95005.4	64697.8	48245.2	0.362	1.215	1.229
39.0	146155.4	108988.1	69736.4	52002.4	0.371	1.247	1.386
40.0	167445.1	124863.8	75025.1	55946.2	0.381	1.279	1.553
41.0	190589.6	142122.7	80569.6	60080.7	0.390	1.311	1.717
42.0	214977.9	160309.0	86375.6	64410.3	0.400	1.343	1.867
43.0	240084.7	179031.1	92448.8	68939.1	0.409	1.375	1.998
44.0	266814.0	198963.2	98795.0	73671.4	0.419	1.407	2.122
45.0	297706.7	221999.9	105419.7	78611.4	0.428	1.439	2.270

Table B17. JHSS: Series 1 PE tests, summary and comparison tables (continued)

JHSS BSS: Stem Bow (ST), Three Displacements, Bare Hull (BH)

VS (knots)	Stem Bow, Bare Hull					
	Exp8	Exp7	Exp9			
	BSS ST BH	BSS ST BH	BSS ST BH	LITE	PE (hp)	PE (hp)
15	5267	6002	4829		5873	7069
16	6396	7330	5873		8429	9972
17	7707	8911	7069		11724	13712
18	9225	10700	8429		15955	18463
19	10919	12682	9972		21229	24227
20	12798	14856	11724		27423	30773
21	14867	17234	13712		34242	37822
22	17176	19851	15955		41543	45497
23	19736	22728	18463		49850	54848
24	22590	25866	21229		60812	68120
25	25711	29260	24227		77172	88342
26	29063	32880	27423		101911	117997
27	32605	36661	30773		136496	157040
28	36273	40569	34242		179019	201691
29	39986	44566	37822		224446	250985
30	43777	48680	41543			
31	47714	53021	45497			
32	51988	57778	49850			
33	56933	63280	54848			
34	62891	69927	60812			
35	70451	78308	68120			
36	80067	88906	77172			
37	92270	102283	88342			
38	107334	118737	101911			
39	125246	138491	117997			
40	145768	161253	136496			
41	168190	186465	157040			
42	191726	213466	179019			
43	215904	241281	201691			
44	241439	269844	224446			
45	271492	300710	250985			

Table B17. JHSS: Series 1 PE tests, summary and comparison tables (continued)

		JHSS BSS: Elliptical Bulb (EB), Three Displacements, Bare Hull (BH)									
		Elliptical Bulb, Bare Hull					Elliptical Bulb vs. Stem Bow				
		Exp11	Exp10	Exp12		Exp11/Exp8	Exp10/Exp7	Exp12/Exp9		Exp11/Exp5	Exp10/Exp4
		BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS
		EB	EB	EB	EB	EB/ST	EB/ST	EB/ST	EB/BB	EB/BB	EB/BB
		BH	BH	BH	BH	BH	BH	BH	BH	BH	BH
		DES	HVY	LITE	LITE	DES	HVY	LITE	DES	HVY	LITE
		PE (hp)	PE (hp)	PE (hp)	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio
VS (knots)	15	5156	5757	4729	0.979	0.979	0.959	0.979	0.921	0.925	0.899
	16	6274	7033	5736	0.981	0.981	0.960	0.977	0.921	0.925	0.897
	17	7523	8482	6888	0.976	0.976	0.952	0.974	0.924	0.932	0.901
	18	8888	10078	8207	0.964	0.964	0.942	0.974	0.929	0.941	0.913
	19	10379	11814	9659	0.951	0.951	0.932	0.969	0.935	0.951	0.927
	20	12020	13694	11248	0.939	0.939	0.922	0.959	0.942	0.958	0.938
	21	13852	15767	12996	0.932	0.932	0.915	0.948	0.949	0.964	0.948
	22	15916	18064	14934	0.927	0.927	0.910	0.936	0.956	0.968	0.955
	23	18247	20629	17096	0.925	0.925	0.908	0.926	0.963	0.972	0.960
	24	20861	23456	19506	0.923	0.923	0.907	0.919	0.969	0.973	0.965
	25	23753	26581	22173	0.924	0.924	0.908	0.915	0.975	0.976	0.969
	26	26891	29949	25091	0.925	0.925	0.911	0.915	0.980	0.978	0.974
	27	30230	33506	28235	0.927	0.927	0.914	0.918	0.985	0.979	0.979
	28	33721	37233	31576	0.930	0.930	0.918	0.922	0.988	0.982	0.985
	29	37335	41083	35094	0.934	0.934	0.922	0.928	0.991	0.985	0.989
	30	41080	45069	38797	0.938	0.938	0.926	0.934	0.993	0.988	0.992
	31	45036	49280	42742	0.944	0.944	0.929	0.939	0.994	0.991	0.995
	32	49364	53903	47056	0.950	0.950	0.933	0.944	0.994	0.994	0.996
	33	54326	59200	51907	0.954	0.954	0.936	0.946	0.995	0.996	0.996
	34	60278	65624	57670	0.958	0.958	0.938	0.948	0.995	0.998	0.997
	35	67645	73720	64655	0.960	0.960	0.941	0.949	0.995	1.000	0.997
	36	76883	83759	73218	0.960	0.960	0.942	0.949	0.995	1.000	0.996
	37	88413	96340	83766	0.958	0.958	0.942	0.948	0.996	1.000	0.997
	38	102538	111897	96516	0.955	0.955	0.942	0.947	0.997	1.000	0.997
	39	119363	130505	111642	0.953	0.953	0.942	0.946	0.998	1.000	0.998
	40	138730	151994	129013	0.952	0.952	0.943	0.945	1.000	1.000	1.000
	41	160111	175903	148208	0.952	0.952	0.943	0.944	1.000	1.000	1.001
	42	183073	201537	168663	0.955	0.955	0.944	0.942	1.000	1.000	1.002
	43	207023	227943	190007	0.959	0.959	0.945	0.942	1.000	0.998	1.001
	44	231809	255690	211913	0.960	0.960	0.948	0.944	0.997	0.996	0.998
	45	258971	285836	236716	0.954	0.954	0.951	0.943	0.991	0.991	0.998

Table B17. JHSS: Series 1 PE tests, summary and comparison tables (continued)

		JHSS BSS: Gooseneck Bulb (GB), Three Displacements, Bare Hull (BH)									
		Gooseneck Bulb, Bare Hull					Gooseneck Bulb vs. Stem Bow				
		Exp14	Exp13	Exp15			Exp14/Exp8	Exp13/Exp7	Exp15/Exp9		
		BSS	BSS	BSS	GB	BH	BSS	GB/ST	BSS	GB/ST	BH
		GB	GB	GB	BH	LITE	GB/ST	BH	GB/ST	BH	LITE
		DES	HVY	PE (hp)	DES	PE Ratio	DES	HVY	PE Ratio	DES	PE Ratio
		5594	6082	5405	1.062	1.013	1.062	1.013	1.119	0.999	1.028
		6624	7358	6389	1.036	1.004	1.036	1.004	1.088	0.972	0.999
		7788	8742	7505	1.011	0.981	1.011	0.981	1.062	0.957	0.982
		9079	10235	8740	0.984	0.957	0.984	0.957	1.037	0.949	0.973
		10509	11857	10100	0.963	0.935	0.963	0.935	1.013	0.947	0.969
		12102	13641	11604	0.946	0.918	0.946	0.918	0.990	0.948	0.968
		13889	15627	13285	0.934	0.907	0.934	0.907	0.969	0.951	0.969
		15905	17853	15179	0.926	0.899	0.926	0.899	0.951	0.955	0.970
		18174	20348	17318	0.921	0.895	0.921	0.895	0.938	0.959	0.973
		20707	23120	19721	0.917	0.894	0.917	0.894	0.929	0.962	0.976
		23494	26158	22389	0.914	0.894	0.914	0.894	0.924	0.965	0.979
		26509	29430	25308	0.912	0.895	0.912	0.895	0.923	0.967	0.982
		29716	32894	28446	0.911	0.897	0.911	0.897	0.924	0.968	0.987
		33078	36510	31769	0.912	0.900	0.912	0.900	0.928	0.970	0.991
		36581	40260	35252	0.915	0.903	0.915	0.903	0.932	0.971	0.993
		40248	44167	38902	0.919	0.907	0.919	0.907	0.936	0.973	0.995
		44166	48324	42774	0.926	0.911	0.926	0.911	0.940	0.975	0.995
		48496	52904	46992	0.933	0.916	0.933	0.916	0.943	0.977	0.995
		53490	58180	51757	0.940	0.919	0.940	0.919	0.944	0.979	0.994
		59478	64515	57348	0.946	0.923	0.946	0.923	0.943	0.981	0.991
		66855	72350	64111	0.949	0.924	0.949	0.924	0.941	0.983	0.988
		76039	82164	72424	0.950	0.924	0.950	0.924	0.938	0.984	0.986
		87418	94422	82652	0.947	0.923	0.947	0.923	0.936	0.985	0.983
		101274	109496	95084	0.944	0.922	0.944	0.922	0.933	0.985	0.982
		117717	127593	109860	0.940	0.921	0.940	0.921	0.931	0.985	0.982
		136626	148673	126917	0.937	0.922	0.937	0.922	0.930	0.985	0.984
		157629	172407	145954	0.937	0.925	0.937	0.925	0.929	0.985	0.986
		180182	198201	166473	0.940	0.928	0.940	0.928	0.930	0.985	0.989
		203766	225319	187931	0.944	0.934	0.944	0.934	0.932	0.984	0.990
		228320	252801	210073	0.946	0.937	0.946	0.937	0.936	0.982	0.990
		254968	282500	233534	0.939	0.939	0.939	0.939	0.930	0.976	0.984
VS	(knots)										
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Table B17. JHSS: Series 1 PE tests, summary and comparison tables (continued)

JHSS BSS: Four Bow Designs, Light Displacement (LTE), Bare Hull (BH)																			
Light Displacement						Bow Bulbs vs. Stem Bow						EB and GB vs. BB							
Exp9	Exp6	Exp12	Exp15	Exp6/Exp9	Exp12/Exp9	Exp15/Exp9	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS
BSS	BSS	BSS	BSS	BSS	BSS	BSS	BB	BB	BB	BB	BB	BB	BB	BB	BB	BB	BB	BB	BB
ST	BB	EB	GB	EB/ST	EB/ST	GB/ST	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH
BH	BH	BH	BH	BH	BH	BH	LITE	LITE	LITE	LITE	LITE	LITE	LITE	LITE	LITE	LITE	LITE	LITE	LITE
LITE	LITE	LITE	LITE	LITE	LITE	LITE	PE (hp)	PE (hp)	PE (hp)	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio
4829	5259	4729	5405	1.089	0.979	1.119	5405	1.089	0.979	1.119	0.899	0.899	1.028	0.899	0.899	1.028	0.899	0.899	1.028
5873	6398	5736	6389	1.089	0.977	1.088	6389	1.089	0.977	1.088	0.897	0.897	0.999	0.897	0.897	0.999	0.897	0.897	0.999
7069	7644	6888	7505	1.081	0.974	1.062	7505	1.081	0.974	1.062	0.901	0.901	0.982	0.901	0.901	0.982	0.901	0.901	0.982
8429	8984	8207	8740	1.066	0.974	1.037	8740	1.066	0.974	1.037	0.913	0.913	0.973	0.913	0.913	0.973	0.913	0.913	0.973
9972	10424	9659	10100	1.045	0.969	1.013	10100	1.045	0.969	1.013	0.927	0.927	0.969	0.927	0.927	0.969	0.927	0.927	0.969
11724	11989	11248	11604	1.023	0.959	0.990	11604	1.023	0.959	0.990	0.938	0.938	0.968	0.938	0.938	0.968	0.938	0.938	0.968
13712	13715	12996	13285	1.000	0.948	0.969	13285	1.000	0.948	0.969	0.948	0.948	0.969	0.948	0.948	0.969	0.948	0.948	0.969
15955	15642	14934	15179	0.980	0.936	0.951	15179	0.980	0.936	0.951	0.955	0.955	0.970	0.955	0.955	0.970	0.955	0.955	0.970
18463	17803	17096	17318	0.964	0.926	0.938	17318	0.964	0.926	0.938	0.960	0.960	0.973	0.960	0.960	0.973	0.960	0.960	0.973
21229	20215	19506	19721	0.952	0.919	0.929	19721	0.952	0.919	0.929	0.965	0.965	0.976	0.965	0.965	0.976	0.965	0.965	0.976
24227	22875	22173	22389	0.944	0.915	0.924	22389	0.944	0.915	0.924	0.969	0.969	0.979	0.969	0.969	0.979	0.969	0.969	0.979
27423	25759	25091	25308	0.939	0.915	0.923	25308	0.939	0.915	0.923	0.974	0.974	0.982	0.974	0.974	0.982	0.974	0.974	0.982
30773	28829	28235	28446	0.937	0.918	0.924	28446	0.937	0.918	0.924	0.979	0.979	0.987	0.979	0.979	0.987	0.979	0.979	0.987
34242	32060	31576	31769	0.936	0.922	0.928	31769	0.936	0.922	0.928	0.985	0.985	0.991	0.985	0.985	0.991	0.985	0.985	0.991
37822	35491	35094	35252	0.938	0.928	0.932	35252	0.938	0.928	0.932	0.989	0.989	0.993	0.989	0.989	0.993	0.989	0.989	0.993
41543	39104	38797	38902	0.941	0.934	0.936	38902	0.941	0.934	0.936	0.992	0.992	0.995	0.992	0.992	0.995	0.992	0.992	0.995
45497	42970	42742	42774	0.944	0.939	0.940	42774	0.944	0.939	0.940	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995
49850	47228	47056	46992	0.947	0.944	0.943	46992	0.947	0.944	0.943	0.996	0.996	0.995	0.996	0.996	0.995	0.996	0.996	0.995
54848	52094	51907	51757	0.950	0.946	0.944	51757	0.950	0.946	0.944	0.996	0.996	0.994	0.996	0.996	0.994	0.996	0.996	0.994
60812	57857	57670	57348	0.951	0.948	0.943	57348	0.951	0.948	0.943	0.997	0.997	0.991	0.997	0.997	0.991	0.997	0.997	0.991
68120	64864	64655	64111	0.952	0.949	0.941	64111	0.952	0.949	0.941	0.997	0.997	0.988	0.997	0.997	0.988	0.997	0.997	0.988
77172	73480	73218	72424	0.952	0.949	0.938	72424	0.952	0.949	0.938	0.996	0.996	0.986	0.996	0.996	0.986	0.996	0.996	0.986
88342	84043	83766	82652	0.951	0.948	0.936	82652	0.951	0.948	0.936	0.997	0.997	0.983	0.997	0.997	0.983	0.997	0.997	0.983
101911	96797	96516	95084	0.950	0.947	0.933	95084	0.950	0.947	0.933	0.998	0.998	0.982	0.997	0.997	0.982	0.997	0.997	0.982
117997	111827	111642	109860	0.948	0.946	0.931	109860	0.948	0.946	0.931	0.998	0.998	0.982	0.997	0.997	0.982	0.997	0.997	0.982
136496	129014	129013	126917	0.945	0.945	0.930	126917	0.945	0.945	0.930	1.000	1.000	0.984	0.998	0.998	0.984	1.000	1.000	0.984
157040	148026	148208	145954	0.943	0.944	0.929	145954	0.943	0.944	0.929	1.001	1.001	0.986	0.998	0.998	0.986	1.001	1.001	0.986
179019	168404	168663	166473	0.941	0.942	0.930	166473	0.941	0.942	0.930	1.002	1.002	0.989	0.999	0.999	0.989	1.002	1.002	0.989
201691	189772	190007	187931	0.941	0.942	0.932	187931	0.941	0.942	0.932	1.001	1.001	0.990	0.999	0.999	0.990	1.001	1.001	0.990
224446	212274	211913	210073	0.946	0.944	0.936	210073	0.946	0.944	0.936	0.998	0.998	0.990	0.998	0.998	0.990	0.998	0.998	0.990
250985	237308	236716	233534	0.946	0.943	0.930	233534	0.946	0.943	0.930	0.998	0.998	0.984	0.998	0.998	0.984	0.998	0.998	0.984

Table B17. JHSS: Series 1 PE tests, summary and comparison tables (continued)

JHSS BSS: Four Bow Designs, Heavy (HVY) & Light (LITE) vs. Design (DES) Displacement, Bare Hull (BH)

VS (knots)	Baseline Bulb				Stem Bow				Elliptical Bulb				Gooseneck Bulb			
	Exp4/5		Exp6/5		Exp7/8		Exp9/8		Exp10/11		Exp12/11		Exp13/14		Exp15/14	
	BSS	BB	BSS	BB	BSS	ST	BSS	ST	BSS	EB	BSS	EB	BSS	GB	BSS	GB
	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH
	HVY/DES	LITE/DES	HVY/DES	LITE/DES	HVY/DES	LITE/DES	HVY/DES	LITE/DES	HVY/DES	LITE/DES	HVY/DES	LITE/DES	HVY/DES	LITE/DES	HVY/DES	LITE/DES
	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio	PE Ratio
15	1.111	0.939	1.140	0.917	1.116	0.917	1.121	0.917	1.116	0.917	1.121	0.917	1.087	0.966	1.087	0.966
16	1.116	0.939	1.146	0.918	1.121	0.918	1.126	0.918	1.121	0.918	1.126	0.918	1.111	0.965	1.111	0.965
17	1.119	0.939	1.156	0.917	1.128	0.917	1.133	0.917	1.128	0.916	1.133	0.916	1.123	0.964	1.123	0.964
18	1.119	0.939	1.160	0.914	1.134	0.914	1.139	0.914	1.134	0.923	1.139	0.923	1.127	0.963	1.127	0.963
19	1.120	0.939	1.161	0.913	1.138	0.913	1.143	0.913	1.138	0.931	1.143	0.931	1.128	0.961	1.128	0.961
20	1.120	0.939	1.161	0.916	1.139	0.916	1.144	0.916	1.139	0.936	1.144	0.936	1.127	0.959	1.127	0.959
21	1.120	0.939	1.159	0.922	1.138	0.922	1.143	0.922	1.138	0.938	1.143	0.938	1.125	0.957	1.125	0.957
22	1.120	0.939	1.156	0.929	1.135	0.929	1.140	0.929	1.135	0.938	1.140	0.938	1.122	0.954	1.122	0.954
23	1.120	0.939	1.152	0.936	1.131	0.936	1.136	0.936	1.131	0.937	1.136	0.937	1.120	0.953	1.120	0.953
24	1.120	0.939	1.145	0.940	1.124	0.940	1.129	0.940	1.124	0.935	1.129	0.935	1.117	0.952	1.117	0.952
25	1.119	0.939	1.138	0.942	1.119	0.942	1.124	0.942	1.119	0.934	1.124	0.934	1.113	0.953	1.113	0.953
26	1.117	0.939	1.131	0.944	1.114	0.944	1.120	0.944	1.114	0.933	1.120	0.933	1.110	0.955	1.110	0.955
27	1.114	0.939	1.124	0.944	1.108	0.944	1.114	0.944	1.108	0.934	1.114	0.934	1.107	0.957	1.107	0.957
28	1.111	0.940	1.118	0.944	1.104	0.944	1.110	0.944	1.104	0.936	1.110	0.936	1.104	0.960	1.104	0.960
29	1.107	0.942	1.115	0.946	1.100	0.946	1.106	0.946	1.100	0.940	1.106	0.940	1.101	0.964	1.101	0.964
30	1.103	0.945	1.112	0.949	1.097	0.949	1.103	0.949	1.097	0.944	1.103	0.944	1.097	0.967	1.097	0.967
31	1.098	0.948	1.111	0.954	1.094	0.954	1.100	0.954	1.094	0.949	1.100	0.949	1.094	0.968	1.094	0.968
32	1.093	0.951	1.111	0.959	1.092	0.959	1.098	0.959	1.092	0.953	1.098	0.953	1.091	0.969	1.091	0.969
33	1.089	0.954	1.111	0.963	1.090	0.963	1.096	0.963	1.090	0.955	1.096	0.955	1.088	0.968	1.088	0.968
34	1.085	0.955	1.112	0.967	1.089	0.967	1.095	0.967	1.089	0.957	1.095	0.957	1.085	0.964	1.085	0.964
35	1.084	0.954	1.112	0.967	1.090	0.967	1.096	0.967	1.090	0.956	1.096	0.956	1.082	0.959	1.082	0.959
36	1.084	0.951	1.110	0.964	1.089	0.964	1.095	0.964	1.089	0.952	1.095	0.952	1.081	0.952	1.081	0.952
37	1.085	0.947	1.109	0.957	1.090	0.957	1.096	0.957	1.090	0.947	1.096	0.947	1.080	0.945	1.080	0.945
38	1.088	0.941	1.106	0.949	1.091	0.949	1.097	0.949	1.091	0.941	1.097	0.941	1.081	0.939	1.081	0.939
39	1.092	0.935	1.106	0.942	1.093	0.942	1.099	0.942	1.093	0.935	1.099	0.935	1.084	0.933	1.084	0.933
40	1.095	0.930	1.106	0.936	1.096	0.936	1.102	0.936	1.096	0.930	1.102	0.930	1.088	0.929	1.088	0.929
41	1.098	0.925	1.109	0.934	1.099	0.934	1.105	0.934	1.099	0.926	1.105	0.926	1.094	0.926	1.094	0.926
42	1.101	0.920	1.113	0.934	1.101	0.934	1.107	0.934	1.101	0.921	1.107	0.921	1.100	0.924	1.100	0.924
43	1.103	0.916	1.118	0.934	1.101	0.934	1.107	0.934	1.101	0.918	1.107	0.918	1.106	0.922	1.106	0.922
44	1.104	0.913	1.118	0.930	1.103	0.930	1.109	0.930	1.103	0.914	1.109	0.914	1.107	0.920	1.107	0.920
45	1.104	0.908	1.108	0.924	1.104	0.924	1.110	0.924	1.104	0.914	1.110	0.914	1.108	0.916	1.108	0.916
AVG	+10.5%	-6.2%	+12.7%	-6.1%	+10.9%	-6.5%	+10.3%	-4.9%								

Table B17. JHSS: Series 1 PE tests, summary and comparison tables (continued)

		JHSS BSS: Baseline Bulb (BB), Design Displacement (DES), Appendage Resistance											
		BSS BB DES						Added Effective Power for Appendages					
VS (knots)		Exp5	Exp3	Exp2	Added PE for Appendages, Combined			Added PE for Shafts and Struts (S&S)			Added PE for Rudders (RUD)		
		BSS	BSS	BSS	DES	DES	DES	DES	DES	DES	DES	DES	DES
		PE (hp)	PE (hp)	PE (hp)	PE (hp)	% of BH	PE (hp)	PE (hp)	% of BH	PE (hp)	% of BH	PE (hp)	% of BH
15		5600	7268	7379	1779	31.8	1668	1668	29.8	111	111	111	2.0
16		6812	8852	8999	2187	32.1	2040	2040	29.9	147	147	147	2.2
17		8139	10581	10796	2657	32.7	2442	2442	30.0	216	216	216	2.6
18		9566	12453	12738	3172	33.2	2887	2887	30.2	285	285	285	3.0
19		11099	14454	14816	3717	33.5	3355	3355	30.2	362	362	362	3.3
20		12765	16601	17050	4285	33.6	3836	3836	30.0	450	450	450	3.5
21		14603	18930	19481	4879	33.4	4327	4327	29.6	551	551	551	3.8
22		16654	21492	22159	5505	33.1	4837	4837	29.0	667	667	667	4.0
23		18955	24335	25132	6176	32.6	5380	5380	28.4	796	796	796	4.2
24		21524	27496	28432	6908	32.1	5973	5973	27.7	936	936	936	4.3
25		24356	30987	32070	7714	31.7	6631	6631	27.2	1083	1083	1083	4.4
26		27426	34793	36030	8604	31.4	7367	7367	26.9	1237	1237	1237	4.5
27		30695	38878	40275	9580	31.2	8183	8183	26.7	1397	1397	1397	4.6
28		34119	43194	44760	10642	31.2	9075	9075	26.6	1567	1567	1567	4.6
29		37674	47702	49454	11780	31.3	10028	10028	26.6	1752	1752	1752	4.7
30		41378	52399	54361	12982	31.4	11020	11020	26.6	1962	1962	1962	4.7
31		45313	57344	59551	14238	31.4	12031	12031	26.6	2207	2207	2207	4.9
32		49642	62683	65182	15539	31.3	13041	13041	26.3	2498	2498	2498	5.0
33		54625	68666	71511	16886	30.9	14041	14041	25.7	2845	2845	2845	5.2
34		60610	75644	78897	18287	30.2	15035	15035	24.8	3252	3252	3252	5.4
35		68010	84056	87773	19763	29.1	16046	16046	23.6	3717	3717	3717	5.5
36		77267	94379	98609	21342	27.6	17112	17112	22.1	4230	4230	4230	5.5
37		88782	107065	111834	23052	26.0	18284	18284	20.6	4769	4769	4769	5.4
38		102845	122457	127762	24917	24.2	19612	19612	19.1	5305	5305	5305	5.2
39		119556	140690	146495	26939	22.5	21135	21135	17.7	5805	5805	5805	4.9
40		138770	161624	167864	29094	21.0	22854	22854	16.5	6240	6240	6240	4.5
41		160097	184817	191418	31321	19.6	24720	24720	15.4	6601	6601	6601	4.1
42		182999	209616	216534	33535	18.3	26617	26617	14.5	6918	6918	6918	3.8
43		207066	235425	242720	35654	17.2	28358	28358	13.7	7295	7295	7295	3.5
44		232542	262260	270207	37666	16.2	29719	29719	12.8	7947	7947	7947	3.4
45		261226	291725	300981	39755	15.2	30499	30499	11.7	9256	9256	9256	3.5

Table B17. JHSS: Series 1 PE tests, summary and comparison tables (continued)

JHSS BSS: Gooseneck Bulb (GB), Design Displacement (DES), Appendage Resistance

VS (knots)	BSS GB DES				Appendages		GB vs. BB			
	Exp14		Exp16&17		Added PE for Appendages, Combined		Exp14/Exp5		Exp16/Exp2	
	BSS GB BH DES	PE (hp)	BSS GB FA DES	PE (hp)	DES PE (hp)	DES % of BH	BSS GB BH DES	PE Ratio	BSS GB FA DES	PE Ratio
15	5594	7631	7631	2037	2037	36.4	0.999	0.999	1.034	1.034
16	6624	9069	9069	2444	2444	36.9	0.972	0.972	1.008	1.008
17	7788	10714	10714	2927	2927	37.6	0.957	0.957	0.992	0.992
18	9079	12558	12558	3479	3479	38.3	0.949	0.949	0.986	0.986
19	10509	14576	14576	4066	4066	38.7	0.947	0.947	0.984	0.984
20	12102	16767	16767	4665	4665	38.6	0.948	0.948	0.983	0.983
21	13889	19162	19162	5272	5272	38.0	0.951	0.951	0.984	0.984
22	15905	21820	21820	5915	5915	37.2	0.955	0.955	0.985	0.985
23	18174	24809	24809	6635	6635	36.5	0.959	0.959	0.987	0.987
24	20707	28154	28154	7447	7447	36.0	0.962	0.962	0.990	0.990
25	23494	31886	31886	8392	8392	35.7	0.965	0.965	0.994	0.994
26	26509	35942	35942	9432	9432	35.6	0.967	0.967	0.998	0.998
27	29716	40218	40218	10502	10502	35.3	0.968	0.968	0.999	0.999
28	33078	44711	44711	11633	11633	35.2	0.970	0.970	0.999	0.999
29	36581	49489	49489	12908	12908	35.3	0.971	0.971	1.001	1.001
30	40248	54424	54424	14176	14176	35.2	0.973	0.973	1.001	1.001
31	44166	59747	59747	15582	15582	35.3	0.975	0.975	1.003	1.003
32	48496	65303	65303	16807	16807	34.7	0.977	0.977	1.002	1.002
33	53490	71535	71535	18046	18046	33.7	0.979	0.979	1.000	1.000
34	59478	78802	78802	19324	19324	32.5	0.981	0.981	0.999	0.999
35	66855	87334	87334	20479	20479	30.6	0.983	0.983	0.995	0.995
36	76039	98111	98111	22072	22072	29.0	0.984	0.984	0.995	0.995
37	87418	111369	111369	23951	23951	27.4	0.985	0.985	0.996	0.996
38	101274	127404	127404	26131	26131	25.8	0.985	0.985	0.997	0.997
39	117717	146155	146155	28438	28438	24.2	0.985	0.985	0.998	0.998
40	136626	167445	167445	30820	30820	22.6	0.985	0.985	0.998	0.998
41	157629	190590	190590	32960	32960	20.9	0.985	0.985	0.996	0.996
42	180182	214978	214978	34796	34796	19.3	0.985	0.985	0.993	0.993
43	203766	240085	240085	36318	36318	17.8	0.984	0.984	0.989	0.989
44	228320	266814	266814	38494	38494	16.9	0.982	0.982	0.987	0.987
45	254968	297707	297707	42739	42739	16.8	0.976	0.976	0.989	0.989

Table B18. JHSS: BSS, bow variations, dynamic sinkage and pitch

Baseline Bulb (BB) Dynamic Conditions										
VS (knots)	Exp5 BSS BB BH DES					Exp2 BSS BB FA DES				
	Sinkage	Sinkage	Pitch	FP Draft	AP Draft	Sinkage	Sinkage	Pitch	FP Draft	AP Draft
	FP (ft)	AP (ft)	Angle (deg)			FP (ft)	AP (ft)	Angle (deg)		
0	0	0	0	28.83	28.83	0	0	0	28.83	28.83
15	0.58	-0.02	-0.04	29.41	28.81	0.57	0.02	-0.03	29.40	28.85
16	0.65	0.00	-0.04	29.48	28.83	0.61	0.01	-0.04	29.44	28.84
18	0.83	-0.01	-0.05	29.66	28.82	0.77	0.03	-0.04	29.60	28.86
20	1.06	-0.06	-0.07	29.89	28.77	1.00	0.01	-0.06	29.83	28.84
22	1.32	-0.12	-0.09	30.15	28.71	1.24	-0.02	-0.08	30.07	28.81
24	1.60	-0.17	-0.11	30.43	28.66	1.48	-0.05	-0.09	30.31	28.78
25	1.75	-0.19	-0.12	30.58	28.64	1.61	-0.06	-0.10	30.44	28.77
26	1.90	-0.22	-0.13	30.73	28.61	1.75	-0.08	-0.11	30.58	28.75
28	2.25	-0.29	-0.15	31.08	28.54	2.08	-0.12	-0.13	30.91	28.71
30	2.69	-0.38	-0.19	31.52	28.45	2.51	-0.17	-0.16	31.34	28.66
32	3.21	-0.48	-0.22	32.04	28.35	3.03	-0.22	-0.20	31.86	28.61
34	3.78	-0.51	-0.26	32.61	28.32	3.58	-0.22	-0.23	32.41	28.61
35	4.04	-0.47	-0.27	32.87	28.36	3.83	-0.16	-0.24	32.66	28.67
36	4.27	-0.36	-0.28	33.10	28.47	4.03	-0.05	-0.25	32.86	28.78
38	4.50	0.08	-0.27	33.33	28.91	4.21	0.41	-0.23	33.04	29.24
40	4.30	0.94	-0.20	33.13	29.77	3.96	1.30	-0.16	32.79	30.13
42	3.60	2.24	-0.08	32.43	31.07	3.22	2.62	-0.04	32.05	31.45
44	2.55	3.77	0.07	31.38	32.60	2.17	4.16	0.12	31.00	32.99
45	2.07	4.46	0.14	30.90	33.29	1.71	4.83	0.19	30.54	33.66

Baseline Bulb (BB) Dynamic Conditions										
VS (knots)	Exp4 BSS BB BH HVY					Exp6 BSS BB BH LITE				
	Sinkage	Sinkage	Pitch	FP Draft	AP Draft	Sinkage	Sinkage	Pitch	FP Draft	AP Draft
	FP (ft)	AP (ft)	Angle (deg)			FP (ft)	AP (ft)	Angle (deg)		
0	0	0	0	30.58	30.58	0	0	0	27.04	27.04
15	0.55	0.00	-0.03	31.13	30.58	0.60	-0.11	-0.04	27.64	26.93
16	0.58	-0.01	-0.04	31.16	30.57	0.69	-0.11	-0.05	27.73	26.93
18	0.76	0.04	-0.04	31.34	30.62	0.89	-0.13	-0.06	27.93	26.91
20	1.00	0.07	-0.06	31.58	30.65	1.13	-0.20	-0.08	28.17	26.84
22	1.24	0.06	-0.07	31.82	30.64	1.39	-0.29	-0.10	28.43	26.75
24	1.48	0.03	-0.09	32.06	30.61	1.66	-0.37	-0.12	28.70	26.67
25	1.61	0.01	-0.10	32.19	30.59	1.81	-0.41	-0.13	28.85	26.63
26	1.75	-0.01	-0.11	32.33	30.57	1.97	-0.44	-0.15	29.01	26.60
28	2.09	-0.06	-0.13	32.67	30.52	2.33	-0.52	-0.17	29.37	26.52
30	2.55	-0.12	-0.16	33.13	30.46	2.77	-0.61	-0.20	29.81	26.43
32	3.11	-0.19	-0.20	33.69	30.39	3.30	-0.71	-0.24	30.34	26.33
34	3.70	-0.20	-0.24	34.28	30.38	3.86	-0.75	-0.28	30.90	26.29
35	3.96	-0.16	-0.25	34.54	30.42	4.13	-0.72	-0.29	31.17	26.32
36	4.17	-0.05	-0.26	34.75	30.53	4.36	-0.63	-0.30	31.40	26.41
38	4.36	0.41	-0.24	34.94	30.99	4.62	-0.21	-0.29	31.66	26.83
40	4.08	1.33	-0.17	34.66	31.91	4.48	0.62	-0.23	31.52	27.66
42	3.30	2.73	-0.04	33.88	33.31	3.86	1.87	-0.12	30.90	28.91
44	2.21	4.37	0.13	32.79	34.95	2.87	3.29	0.03	29.91	30.33
45	1.74	5.07	0.20	32.32	35.65	2.38	3.88	0.09	29.42	30.92

Table B18. JHSS: BSS, bow variations, dynamic sinkage and pitch (continued)

Stem Bow (ST) Dynamic Conditions					
VS (knots)	Exp8 BSS ST BH DES				
	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)
0	0	0	0	29.11	29.11
15	0.62	-0.01	-0.04	29.73	29.10
16	0.66	-0.01	-0.04	29.77	29.10
18	0.83	-0.03	-0.05	29.94	29.08
20	1.07	-0.07	-0.07	30.18	29.04
22	1.34	-0.11	-0.09	30.45	29.00
24	1.61	-0.15	-0.11	30.72	28.96
25	1.75	-0.16	-0.12	30.86	28.95
26	1.90	-0.18	-0.13	31.01	28.93
28	2.25	-0.24	-0.15	31.36	28.87
30	2.70	-0.33	-0.18	31.81	28.78
32	3.24	-0.43	-0.22	32.35	28.68
34	3.81	-0.46	-0.26	32.92	28.65
35	4.06	-0.42	-0.27	33.17	28.69
36	4.28	-0.32	-0.28	33.39	28.79
38	4.48	0.16	-0.26	33.59	29.27
40	4.23	1.10	-0.19	33.34	30.21
42	3.46	2.51	-0.06	32.57	31.62
44	2.35	4.11	0.11	31.46	33.22
45	1.84	4.78	0.18	30.95	33.89

Stem Bow (ST) Dynamic Conditions										
VS (knots)	Exp7 BSS ST BH HVY					Exp9 BSS ST BH LITE				
	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)
0	0	0	0	30.86	30.86	0	0	0	27.33	27.33
15	0.61	0.08	-0.03	31.47	30.94	0.59	-0.12	-0.04	27.92	27.21
16	0.65	0.08	-0.03	31.51	30.94	0.70	-0.13	-0.05	28.03	27.20
18	0.85	0.15	-0.04	31.71	31.01	0.93	-0.14	-0.06	28.26	27.19
20	1.10	0.18	-0.05	31.96	31.04	1.19	-0.19	-0.08	28.52	27.14
22	1.31	0.16	-0.07	32.17	31.02	1.46	-0.25	-0.10	28.79	27.08
24	1.51	0.11	-0.08	32.37	30.97	1.72	-0.32	-0.12	29.05	27.01
25	1.62	0.09	-0.09	32.48	30.95	1.86	-0.36	-0.13	29.19	26.97
26	1.75	0.07	-0.10	32.61	30.93	2.01	-0.39	-0.15	29.34	26.94
28	2.09	0.03	-0.12	32.95	30.89	2.36	-0.48	-0.17	29.69	26.85
30	2.55	-0.01	-0.15	33.41	30.85	2.82	-0.59	-0.21	30.15	26.74
32	3.12	-0.07	-0.19	33.98	30.79	3.37	-0.71	-0.25	30.70	26.62
34	3.70	-0.07	-0.23	34.56	30.79	3.96	-0.76	-0.28	31.29	26.57
35	3.95	-0.02	-0.24	34.81	30.84	4.22	-0.73	-0.30	31.55	26.60
36	4.15	0.09	-0.24	35.01	30.95	4.45	-0.63	-0.31	31.78	26.70
38	4.28	0.59	-0.22	35.14	31.45	4.67	-0.18	-0.29	32.00	27.15
40	3.95	1.60	-0.14	34.81	32.46	4.45	0.72	-0.23	31.78	28.05
42	3.11	3.13	0.00	33.97	33.99	3.72	2.07	-0.10	31.05	29.40
44	1.92	4.84	0.18	32.78	35.70	2.67	3.59	0.06	30.00	30.92
45	1.34	5.48	0.25	32.20	36.34	2.20	4.20	0.12	29.53	31.53

Table B18. JHSS: BSS, bow variations, dynamic sinkage and pitch (continued)

Elliptical Bulb (EB) Dynamic Conditions					
VS (knots)	Exp11 BSS EB BH DES				
	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)
0	0	0	0	28.93	28.93
15	0.50	-0.12	-0.04	29.43	28.81
16	0.74	0.06	-0.04	29.67	28.99
18	0.93	0.10	-0.05	29.86	29.03
20	1.07	-0.02	-0.07	30.00	28.91
22	1.28	-0.12	-0.08	30.21	28.81
24	1.56	-0.17	-0.10	30.49	28.76
25	1.71	-0.18	-0.11	30.64	28.75
26	1.86	-0.19	-0.12	30.79	28.74
28	2.21	-0.23	-0.15	31.14	28.70
30	2.64	-0.31	-0.18	31.57	28.62
32	3.16	-0.41	-0.21	32.09	28.52
34	3.73	-0.46	-0.25	32.66	28.47
35	4.01	-0.43	-0.27	32.94	28.50
36	4.24	-0.33	-0.28	33.17	28.60
38	4.47	0.11	-0.26	33.40	29.04
40	4.20	0.96	-0.19	33.13	29.89
42	3.38	2.24	-0.07	32.31	31.17
44	2.34	3.77	0.09	31.27	32.70
45	2.05	4.50	0.15	30.98	33.43

Elliptical Bulb (EB) Dynamic Conditions										
VS (knots)	Exp10 BSS EB BH HVY					Exp12 BSS EB BH LITE				
	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)
0	0	0	0	30.68	30.68	0	0	0	27.15	27.15
15	0.47	-0.04	-0.03	31.15	30.64	0.48	-0.23	-0.04	27.63	26.92
16	0.58	-0.02	-0.04	31.26	30.66	0.61	-0.15	-0.05	27.76	27.00
18	0.73	0.00	-0.04	31.41	30.68	0.86	-0.12	-0.06	28.01	27.03
20	0.90	-0.01	-0.05	31.58	30.67	1.09	-0.21	-0.08	28.24	26.94
22	1.13	-0.03	-0.07	31.81	30.65	1.32	-0.32	-0.10	28.47	26.83
24	1.39	-0.05	-0.09	32.07	30.63	1.57	-0.40	-0.12	28.72	26.75
25	1.54	-0.05	-0.10	32.22	30.63	1.70	-0.42	-0.13	28.85	26.73
26	1.69	-0.06	-0.11	32.37	30.62	1.85	-0.45	-0.14	29.00	26.70
28	2.05	-0.09	-0.13	32.73	30.59	2.22	-0.49	-0.16	29.37	26.66
30	2.49	-0.16	-0.16	33.17	30.52	2.69	-0.56	-0.20	29.84	26.59
32	3.03	-0.23	-0.20	33.71	30.45	3.24	-0.65	-0.23	30.39	26.50
34	3.61	-0.26	-0.23	34.29	30.42	3.81	-0.70	-0.27	30.96	26.45
35	3.88	-0.22	-0.25	34.56	30.46	4.07	-0.67	-0.29	31.22	26.48
36	4.09	-0.12	-0.25	34.77	30.56	4.29	-0.58	-0.29	31.44	26.57
38	4.29	0.35	-0.24	34.97	31.03	4.53	-0.16	-0.28	31.68	26.99
40	3.99	1.28	-0.17	34.67	31.96	4.37	0.71	-0.22	31.52	27.86
42	3.14	2.68	-0.03	33.82	33.36	3.74	2.01	-0.10	30.89	29.16
44	1.99	4.31	0.14	32.67	34.99	2.74	3.43	0.04	29.89	30.58
45	1.54	4.99	0.21	32.22	35.67	2.20	3.95	0.11	29.35	31.10

Table B18. JHSS: BSS, bow variations, dynamic sinkage and pitch (continued)

Gooseneck Bulb (GB) Dynamic Conditions										
VS (knots)	Exp14 BSS GB BH DES					Exp16&17 BSS GB FA DES				
	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)
0	0	0	0	28.82	28.82	0	0	0	28.82	28.82
15	0.56	-0.01	-0.03	29.38	28.81	0.51	0.00	-0.03	29.33	28.82
16	0.61	-0.03	-0.04	29.43	28.79	0.58	0.01	-0.03	29.40	28.83
18	0.80	-0.02	-0.05	29.62	28.80	0.73	0.02	-0.04	29.55	28.84
20	1.03	-0.04	-0.06	29.85	28.78	0.93	0.00	-0.06	29.75	28.82
22	1.28	-0.09	-0.08	30.10	28.73	1.18	-0.03	-0.07	30.00	28.79
24	1.53	-0.15	-0.10	30.35	28.67	1.44	-0.05	-0.09	30.26	28.77
25	1.66	-0.18	-0.11	30.48	28.64	1.57	-0.06	-0.10	30.39	28.76
26	1.80	-0.20	-0.12	30.62	28.62	1.71	-0.07	-0.11	30.53	28.75
28	2.14	-0.25	-0.14	30.96	28.57	2.02	-0.09	-0.13	30.84	28.73
30	2.59	-0.31	-0.17	31.41	28.51	2.41	-0.14	-0.15	31.23	28.68
32	3.14	-0.37	-0.21	31.96	28.45	2.90	-0.20	-0.19	31.72	28.62
34	3.73	-0.39	-0.25	32.55	28.43	3.43	-0.19	-0.22	32.25	28.63
35	4.00	-0.35	-0.26	32.82	28.47	3.68	-0.14	-0.23	32.50	28.68
36	4.22	-0.26	-0.27	33.04	28.56	3.89	-0.02	-0.24	32.71	28.80
38	4.43	0.16	-0.26	33.25	28.98	4.10	0.45	-0.22	32.92	29.27
40	4.17	1.00	-0.19	32.99	29.82	3.86	1.35	-0.15	32.68	30.17
42	3.40	2.28	-0.07	32.22	31.10	3.08	2.67	-0.02	31.90	31.49
44	2.37	3.78	0.08	31.19	32.60	1.99	4.21	0.13	30.81	33.03
45	1.96	4.43	0.15	30.78	33.25	1.54	4.87	0.20	30.36	33.69

Gooseneck Bulb (GB) Dynamic Conditions										
VS (knots)	Exp13 BSS GB BH HVY					Exp15 BSS GB BH LITE				
	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)	Sinkage FP (ft)	Sinkage AP (ft)	Pitch Angle (deg)	FP Draft (ft)	AP Draft (ft)
0	0	0	0	30.57	30.57	0	0	0	27.04	27.04
15	0.64	0.13	-0.03	31.21	30.70	0.63	-0.03	-0.04	27.67	27.01
16	0.67	0.12	-0.03	31.24	30.69	0.67	-0.09	-0.05	27.71	26.95
18	0.83	0.15	-0.04	31.40	30.72	0.83	-0.11	-0.06	27.87	26.93
20	1.04	0.14	-0.05	31.61	30.71	1.06	-0.15	-0.07	28.10	26.89
22	1.24	0.09	-0.07	31.81	30.66	1.32	-0.22	-0.09	28.36	26.82
24	1.46	0.04	-0.09	32.03	30.61	1.59	-0.30	-0.11	28.63	26.74
25	1.58	0.02	-0.09	32.15	30.59	1.72	-0.33	-0.12	28.76	26.71
26	1.73	0.01	-0.10	32.30	30.58	1.87	-0.37	-0.13	28.91	26.67
28	2.08	-0.01	-0.13	32.65	30.56	2.20	-0.43	-0.16	29.24	26.61
30	2.55	-0.05	-0.16	33.12	30.52	2.62	-0.50	-0.19	29.66	26.54
32	3.10	-0.12	-0.19	33.67	30.45	3.13	-0.58	-0.22	30.17	26.46
34	3.66	-0.17	-0.23	34.23	30.40	3.67	-0.63	-0.26	30.71	26.41
35	3.90	-0.15	-0.24	34.47	30.42	3.92	-0.61	-0.27	30.96	26.43
36	4.10	-0.07	-0.25	34.67	30.50	4.14	-0.54	-0.28	31.18	26.50
38	4.27	0.37	-0.23	34.84	30.94	4.37	-0.16	-0.27	31.41	26.88
40	4.03	1.33	-0.16	34.60	31.90	4.21	0.66	-0.21	31.25	27.70
42	3.32	2.81	-0.03	33.89	33.38	3.59	1.93	-0.10	30.63	28.97
44	2.22	4.43	0.13	32.79	35.00	2.67	3.36	0.04	29.71	30.40
45	1.64	5.00	0.20	32.21	35.57	2.25	3.89	0.10	29.29	30.93

Table B19. JHSS: BSS, bow variations, BH, DES, wave traces on hull surface, 36 knots

Wave Trace on Hull Surface*					Dynamic Draft					Equivalent Local Wave Height Generated ⁺				
Station	Exp5	Exp8	Exp11	Exp14	Station	Exp5	Exp8	Exp11	Exp14	Station	Exp5	Exp8	Exp11	Exp14
	BSS	BSS	BSS	BSS		BSS	BSS	BSS	BSS		BSS	BSS	BSS	BSS
	BB	ST	EB	GB		BB	ST	EB	GB		BB	ST	EB	GB
	BH	BH	BH	BH		BH	BH	BH	BH		BH	BH	BH	BH
	DES	DES	DES	DES		DES	DES	DES	DES		DES	DES	DES	DES
36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots	36 knots
0	39.6	36.2	39.3	38.7	0	33.1	33.4	33.2	33.0	0	6.5	2.8	6.1	5.7
0.5	44.1	41.0	43.3	43.3	0.5	33.0	33.3	33.1	32.9	0.5	11.1	7.7	10.2	10.3
1	43.6	42.4	42.7	41.0	1	32.9	33.2	32.9	32.8	1	10.7	9.3	9.8	8.2
1.5	40.1	39.6	41.0	39.6	1.5	32.8	33.0	32.8	32.7	1.5	7.4	6.5	8.2	6.9
2	38.4	37.9	39.9	38.7	2	32.6	32.9	32.7	32.6	2	5.8	4.9	7.2	6.1
2.5	36.7	36.2	37.6	37.3	2.5	32.5	32.8	32.6	32.5	2.5	4.2	3.4	5.0	4.8
3	35.3	34.5	35.9	35.9	3	32.4	32.7	32.5	32.4	3	2.9	1.8	3.4	3.5
3.5	33.9	33.0	34.7	34.5	3.5	32.3	32.6	32.4	32.3	3.5	1.6	0.5	2.4	2.2
4	33.9	32.2	33.9	33.9	4	32.2	32.5	32.3	32.1	4	1.7	-0.3	1.6	1.7
4.5	34.2	31.6	33.3	33.0	4.5	32.1	32.4	32.1	32.0	4.5	2.1	-0.7	1.2	1.0
5	34.2	31.6	33.0	32.8	5	31.9	32.2	32.0	31.9	5	2.2	-0.6	1.0	0.8
6	31.9	31.9	31.9	31.9	6	31.7	32.0	31.8	31.7	6	0.2	-0.1	0.1	0.2
7	31.1	31.9	31.1	31.1	7	31.5	31.8	31.6	31.5	7	-0.4	0.1	-0.5	-0.4
8	31.1	31.9	29.6	29.6	8	31.2	31.6	31.3	31.2	8	-0.2	0.4	-1.7	-1.6
9	28.8	29.3	28.8	28.8	9	31.0	31.3	31.1	31.0	9	-2.2	-2.0	-2.3	-2.2
10	26.8	28.2	25.6	25.6	10	30.8	31.1	30.9	30.8	10	-4.0	-2.9	-5.2	-5.2
11	26.2	28.5	26.2	26.2	11	30.6	30.9	30.7	30.6	11	-4.3	-2.4	-4.4	-4.4
12	27.6	28.8	27.1	27.1	12	30.3	30.6	30.4	30.4	12	-2.7	-1.9	-3.4	-3.3
13	28.2	29.3	28.2	28.2	13	30.1	30.4	30.2	30.1	13	-1.9	-1.1	-2.0	-1.9
14	28.8	29.9	28.2	28.2	14	29.9	30.2	30.0	29.9	14	-1.1	-0.3	-1.8	-1.7
15	29.9	29.9	29.9	29.9	15	29.6	29.9	29.7	29.7	15	0.3	0.0	0.2	0.2
16	31.1	30.8	31.1	31.1	16	29.4	29.7	29.5	29.5	16	1.7	1.1	1.5	1.6
17	31.1	30.8	30.8	30.8	17	29.2	29.5	29.3	29.2	17	1.9	1.3	1.5	1.5
18	32.8	31.3	31.3	31.3	18	28.9	29.3	29.1	29.0	18	3.8	2.1	2.3	2.3
19	33.3	31.3	31.3	31.3	19	28.7	29.0	28.8	28.8	19	4.6	2.3	2.5	2.6
20	33.3	31.3	31.3	31.3	20	28.5	28.8	28.6	28.6	20	4.9	2.5	2.7	2.8

*Height (ft) Above Ship Baseline

⁺Wave Height (ft) Above Free Surface

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